FOR THE PEOPLE
FOR EDVCATION
FOR SCIENCE

LIBRARY
OF
THE AMERICAN MUSEUM
OF
NATURAL HISTORY

AMERICAN MUSEUM OF NATURAL HISTORY CENTRAL PARK NEW YORK

56.06(42)
9

PALÆONTOGRAPHICAL SOCIETY.

VOLUME XXIII.

CONTAINING

SUPPLEMENT TO THE FOSSIL CORALS. Part II.—No. 2 (Cretaceous). By Dr. Duncan. Six Plates.

THE CRETACEOUS ECHINODERMATA. Vol. I.—Part III. By Dr. Wright. Ten Plates.

THE BELEMNITIDÆ. Part V (Oxford Clay, &c., Belemnites). By Prof. Phillips. Nine Plates.

THE FISHES OF THE OLD RED SANDSTONE. Part I (*concluded*). By Messrs. J. Powrie and E. Ray Lankester. Nine Plates.

THE REPTILIA OF THE LIASSIC FORMATIONS. Part II. By Prof. Owen. Four Plates.

THE CRAG CETACEA. No. I (Ziphius). By Prof. Owen. Five Plates.

ISSUED FOR 1869.

JANUARY, 1870.

Council and Officers elected 9th April, 1869.

President.

J. S. BOWERBANK, LL.D., F.R.S., G.S.

Vice-Presidents.

T. Davidson, Esq., F.R.S., G.S.
Sir R. I. Murchison, Bart., F.R.S., G.S.
Prof. Owen, M.D., F.R.S., G.S.
Prof. Phillips, F.R.S., G.S.

Council.

Prof. Ansted, M.A., F.R.S., G.S.
Antonio Brady, Esq., F.G.S.
W. Boyd Dawkins, Esq., F.R.S., G.S.
P. M. Duncan, M.B., F.R.S., Sec. G.S.
R. Etheridge, Esq., F.G.S.
J. W. Flower, Esq., F.G.S.
Prof. Huxley, LL.D., F.R.S., G.S.
J. W. Ilott, Esq.
J. Gwyn Jeffreys, Esq., F.R.S., G.S.
H. Lee, Esq., F.L.S., G.S.
W. H. Leighton, Esq., F.G.S.
J. Pickering, Esq.
J. Prestwich, Esq., F.R.S., G.S.
Prof. Tennant, F.G.S., Z.S.
C. Tyler, Esq., F.L.S., G.S.
H. Woodward, Esq., F.G.S., Z.S.

Treasurer.

Searles Wood, Esq., F.G.S., Brentwood, Essex.

Honorary Secretary.

Rev. T. Wiltshire, M.A., F.G.S., 13, Granville Park, Lewisham, Kent, S.E.

Local Secretaries.

Alton—Wm. Curtis, Jun., Esq.
Bath—Wm. Walton, Esq.
Berlin—Messrs. Friedländer & Son.
Birkenhead—Wm. Ferguson, Esq.
Birmingham—W. Mathews, Jun., Esq., F.G.S.
Blackburn—Wm. Harrison, Esq., F.G.S.
Bristol—Wm. Sanders, Esq., F.R.S., G.S.
Cambridge—James Carter, Esq.
Cheltenham—T. Wright, M.D., F.G.S.
Cirencester—J. Bravender, Esq., F.G.S.
Colchester—C. R. Bree, M.D.
Deddington—Chas. Faulkner, Esq., F.S.A., G.S., R.G.S.
Devizes—Wm. Cunnington, Esq., F.G.S.
Dublin—W. E. Steele, M.D., F.R.D.S.
Edinburgh—Prof. Balfour, M.D., F.R.S., L.S.
Guildford—R. A. C. Godwin-Austen, Esq., F.R.S., G.S.
Kendal—Thomas Gough, Esq.
Leeds—Thos. Nunneley, Esq.
Leicester—James Plant, Esq.
Liverpool—G. H. Morton, Esq., F.G.S.
New York.—B. Waterhouse Hawkins, Esq., F.L.S., G.S.
Norfolk—Rev. J. Gunn, M.A., F.G.S.
Oxford—Prof. J. Phillips, F.R.S., G.S.
Paris—M. F. Savy, 24, Rue Hautefeuille.
Plymouth—J. H. Fuge, Esq.
Richmond, Yorkshire—Edward Wood, Esq., F.G.S.
Scarborough—John Leckenby, Esq., F.G.S.
Tonbridge Wells—J. Sharp, Esq., F.G.S.
Torquay—Wm. Pengelley, Esq., F.R.S., G.S.
Wolverhampton—Hy. Beckett, Esq., F.G.S.

LIST OF MEMBERS.*

JANUARY, 1870.

HER MOST GRACIOUS MAJESTY THE QUEEN.

Adams, William, Esq., F.G.S., Cardiff, Glamorganshire.
Adlard, J. E., Esq., Bartholomew Close, E.C.
Albert Memorial Museum, Queen Street, Exeter.
Aitken, John, Esq., Lane End, Bacup, Manchester.
Allport, S., Esq., Snow Hill, Birmingham.
Angelin, Professor, Stockholm.
Ansted, Professor D. T., M.A., F.R.S., G.S., &c., Athenæum Club; and 33, Brunswick Square, W.C.
Arbuthnot, Capt. W., 25, Hyde Park Gardens, W.
Asher and Co., Messrs., 13, Bedford Street, Covent Garden, W.C.
Athenæum Library, Liverpool.
Auerbach, Professor, Moscow.
Austen, Rev. J. H., M.A., Ensbury House, Wimborne.
Austen, Miss Helena E., 19, Henrietta Street, Bath.
Aveline, W. T., Esq., F.G.S., Museum of Practical Geology, Jermyn Street, S.W.

Backhouse, Edward, Esq., Ashburne House, Sunderland.
Bair, M., Frankfort.
Balfour, Professor, M.D., F.R.S., L.S., &c., *Local Secretary*, 27, Inverleith Row, Edinburgh.
Balme, E. B. Wheatley, Esq., Loughrigg, Ambleside.
Barclay, Joseph G., Esq., 54, Lombard Street, E.C.
Barlow, H. C., M.D., F.G.S., 11, Church Yard Row, Newington Butts, Surrey, S.
Barr, W. R., Esq., Park Mills, Stockport.
Barthes and Lowell, Messrs., 14, Great Marlborough Street, W.
Bath Royal Literary and Scientific Institution.
Bathurst, Rev. W. H., Lydney Park, Gloucester.
Battersby, R., M.D., Torquay.
Beaufoy, George, Esq. (Executor of the late), South Lambeth, S.
Becker, M. Edvald, Breslau, Silesia.
Beckett, Henry, Esq. F.G.S., *Local Secretary*, Darlington Street, Wolverhampton.

* The Members are requested to inform the Secretary of any errors or omissions in this list, and of any delay in the transmission of the Yearly Volumes.

Bell, Professor T., F.R.S., L.S., G.S., &c., The Wakes, Selborne, Alton, Hants.
Benson, Starling, Esq., F.G.S., Swansea.
Bernard, Ralph M., Esq., 5, Victoria Square, Clifton.
Bewley, John, Esq., 4, Brown's Buildings, Liverpool.
Bigsby, J. J., M.D., F.R.S., G.S., 89, Gloucester Place, Portman Square, W.
Bilke, Edward, Esq., F.G.S., &c., 1, Chester Square, Pimlico, S.W.
Binney, E. W., Esq., F.R.S., G.S., &c., 40, Cross Street, Manchester.
Birmingham Free Library, Radcliffe Place, Birmingham.
Birmingham Old Library, Union Street, Birmingham.
Blackburne, Major John George, F.G.S., Oldham.
Blackmore, Humphrey P., M.D., Salisbury.
Bladon, James, Esq., Pontypool.
Blake, W., Esq., Bridge House, South Petherton.
Blanford, H. F., Esq., F.G.S., 21, Bouverie Street, Whitefriars, E.C.
Boase, H. S., M.D., F.R.S., G.S., &c., Claverhouse, near Dundee.
Bohn, Henry G., Esq., 18, Henrietta Street, Covent Garden, W.C.
Bonney, Rev. George, F.G.S., St. John's College, Cambridge.
Bordeaux, La Faculté des Sciences de.
Borradaile, Charles, Esq., East Hothly, Hurst Green, Sussex.
Bosquet, Mons. J., For. Cor. G.S., Pharmacien, Maestricht.
Boston Society of Natural History, Boston, U.S.A.
Bower, Rev. E., Closworth, near Yeovil.
Bowerbank, J. S., LL.D., F.R.S., &c., *President*, 2, East Ascent, St. Leonard's-on-Sea.
Bradford Philosophical Society, 31, Manor Row, Bradford.
Brady, Antonio, Esq., F.G.S., Stratford, Essex; and Admiralty Office, Somerset House, W.C.
Brady, Sir M., Bart., 26, Upper Pembroke Street, Dublin.
Braikenridge, Rev. G. W., M.A., F.S.A., G.S., &c., Clevedon, near Bristol.
Brassey, Thomas, Esq., jun., 56, Lowndes Square, S.W.
Bravender, John, Esq., F.G.S., *Local Secretary*, Coxwell Street, Cirencester.
Bree, C. R., M.D., *Local Secretary*, East Hill, Colchester.
Briggs, General John, F.R.S., G.S., &c., Oriental Club, Hanover Square, W.; and Bridge Lodge, Hurstpierpont.
Briggs, Miss Ellen, 55, Lincoln's Inn Fields.
Brighton and Sussex Natural History Society, 7, Pavilion Parade, Brighton.
British Museum, Printed Book Department, W.C.
British Museum, Departmental Mineralogical and Geological Library, W.C.
Broome, C. E., Esq., M.A., &c., Elmhurst, Batheaston, Bath.
Brown, Edwin, Esq., F.R.G.S., G.S., Burton-on-Trent.
Brown, Isaac, Esq., Ackworth, Pontifract.
Brown, T. C., Esq., Cirencester.
Browne, Wm. Meredith, Esq., Westminster Fire Office, King Street, Covent Garden, W.C.
Buckman, Professor James, F.G.S., &c., Bradford Abbas, Sherborne, Dorset.
Busk, George, Esq., F.R.S., L.S., &c., 32, Harley Street, Cavendish Square, W.

Cambridge University Library.
Carpenter, Alfred, M.D., Croydon, S.
Carpenter, W. B., M.D., F.R.S., &c., 56, Regent's Park Road, N.W.
Carter, James, Esq., *Local Secretary*, 30, Petty Cury, Cambridge.

Cassini, H. T., Esq., Victoria Cottage, Archway Road, Highgate, N.
Cavell, Edmund, Esq., F.G.S., Saxmundham.
Chamberlin, Rev. T., C.B.
Chambers, Robert, Esq., F.R.S.E., G.S., &c., St. Andrew's.
Champernowne, Arthur, Esq., Darlington Hall, Totness, Devonshire.
Chapman, Thomas, Esq., 14, Cockspur Street, Charing Cross, S.W.
Cheltenham Permanent Library, 18, Clarence Street, Cheltenham.
Cherbullier, Mons., Paris.
Christ's College, Cambridge, Library of.
Clabon, J. M., Esq., 21, Great George Street, S.W.
Clark, Dr. W., F.R.S., &c., Cambridge.
Clarke, Rev. W. B., F.G.S., &c., St. Leonards, near Sydney, New South Wales.
Clayton, Rev. J. H., Liphook, Hants.
Cobbold, Rev. R. H., Rectory, Broseley, Salop.
Cocchi, Sig. Q., Professor of Geology, Florence.
Colchester, W., Esq., F.G.S., Grundesburgh Hall, Ipswich.
Collings, Rev. W. T., M.A., F.L.S., G.S., Lord of Sark, Channel Islands.
Collingwood, F. J. W., Esq., Glanton Pyke, Glanton, Northumberland.
Colvin, Col. John, C.B., Leintwardine, near Ludlow.
Compton, Rev. John, Minesteed Parsonage, Lyndhurst.
Cooper, Charles J., Esq., Bridgenorth, Salop.
Cornalia, Prof. Emilio, Milan.
Cornthwaite, Rev. T. M., M.A., Walthamstow.
Corporation of London, Library Committee of, Guildhall, E.C.
Corrie, Adam J., Esq., M.A., Quintella, Torquay.
Cotteau, Mons., Paris.
Cranage, Dr. J. E., The Old Hall, Wellington, Shropshire.
Crickitt, E., Esq., 4, Belvedere Villas, Bath.
Crisp, F., Esq., 131, Adelaide Road, N.W.
Cross, Rev. J. E., Appleby Vicarage, Brigg, Lincolnshire.
Cross, R. A., Esq., Hill Cliff, Warrington.
Crowley, Alfred, Esq., Bramley Oaks, Croydon, S.
Cubitt, George, Esq., M.P., F.G.S., 17, Princes Gate, W.
Cull, R., Esq., 13, Tavistock Street, Bedford Square, W.C.
Cunnington, W., Esq., F.G.S., *Local Secretary*, Devizes, Wilts.
Curtis, W., Esq., *Local Secretary*, Alton, Hants.
Currey, Elliot S., Esq., Erlwood, Bagshot.
Cust, Lady Elizabeth, 13, Eccleston Square, S.W.

Darwin, Charles, Esq., M.A., F.R.S., G.S., &c., Down, Bromley, Kent.
Davidson, Thomas, Esq., F.R.S., G.S., Mem. Geol. Soc. France, &c., *Vice-President*, 22 Park Crescent, Brighton.
Daw, E., Esq., Mynfield, Amwell, Ware.
Dawkins, W. Boyd, Esq., F.R.S., G.S., Birch View, Norman Road, Rusholme, Manchester.
Dawson, Principal J. W., LL.D., F.R.S., G.S., &c., McGill's University, Montreal.
Day, Rev. Hen. Geo., M.A., Sedbergh, Kendal.
Deane, H., Esq., F.L.S., Clapham Common, Surrey, S.W.

De Gray and Ripon, Earl, 1, Belgrave Square, S.W.
Denison, Col. Sir William, R.E., K.C.B., F.R.S., R.A.S., Observatory, East Sheen, S.W.
Deshayes, Mons. G. P., F.M.G.S., Paris.
Devonshire, Duke of, Chancellor of the University of London, F.R.S., G.S., &c., Devonshire House, Piccadilly, W.
Devon and Exeter Institution, Exeter (by Ed. Parfitt, Esq.)
Dewilde, G. R., Esq., 14, Peak Hill Avenue, Sydenham.
Dickinson, F. H., Esq., King Weston, Somerton.
Dickinson, W., Esq., Thorncroft, Workington.
Dickinson, W., Esq., 6, Princes Street, Lothbury, E.C.
Digby, Lady, Minterne, near Dorchester.
Dilke, Sir C. Wentworth, Bart., F.G.S., L.S., &c., 76, Sloane Street, S.W.
Dollfus, Mons., Paris.
Dorset County Museum Library, Dorchester.
Douglas, Rev. Robert, Manaton Rectory, Moreton-Hampstead, Exeter.
Dover Proprietary Library.
Doyen, Mons. J. M.
Ducie, the Earl of, F.R.S., G.S., &c., Belgrave Square, S.W.
Dudley and Midland Geological and Scientific Society and Field-Club.
Dumortier, Mons. E., Lyons (by Mons. F. Savy, Paris).
Duncan, P. M., M.B., F.R.S., Sec.G.S., 40, Blessington Road, Lee, S.E.
Durham, the Dean and Chapter of (by Samuel Rowlandson, Esq., the College, Durham).
Dyer, Prof. W. T., Royal Agricultural College, Cirencester.

Eccles, James, Esq., Springwell House, Blackburn.
Edgell, Rev. E. Wyatt, 2, Lansdowne Terrace, Ladbroke Square, Notting Hill, W.
Edinburgh Geological Society, 5, St. Andrew Square, Edinburgh.
Edinburgh Museum of Science and Art, Argyle Square, Edinburgh.
Edwards, F. E., Esq., F.G.S., 22, Woburn Square, W.C.
Egerton, Sir Philip de Malpas Grey, Bart., M.P., Trustee Brit. Museum, F.R.S., G.S., &c., Oulton Park, Cheshire; and 28B, Albemarle Street, W.
Elliott, John, Esq., Kingsbridge, Devon.
Elliot, Sir Walter, K.S.I., F.L.S., Wolfelee, Hawick, N.B.
Enniskillen, William Willoughby, Earl of, D.C.L., F.R.S., G.S., &c., Florence Court, Enniskillen; and 65, Eaton Place.
Eskrigge, R. A., Esq., 3, Batavia Buildings, Liverpool.
Etheridge, R., Esq., F.G.S., &c., Museum of Practical Geology, Jermyn Street, S.W.
Evans, John, Esq., F.R.S., Sec.G.S., Nash Mills, Hemel Hempstead.
Evans, Thomas, M.D., Gloucester.
Eyton, Thomas C., Esq., F.L.S., G.S., &c., Eyton, near Wellington, Salop.

Falconer, Thomas, Esq., F.G.S., Usk, Monmouthshire.
Falkner, Frederick, Esq., Somersetshire Bank, Bath.
Faulkner, Charles, Esq., F.S.A., G.S., R.G.S., *Local Secretary*, Museum, Deddington, Oxon.
Favre, Mons. Alph., Professor of Geology, Academy, Geneva.

Ferguson, William, Esq., F.L.S., G.S., R.G.S., &c., *Local Secretary*, Kinmundy, Mintlaw, Aberdeenshire; and 2, St. Aidan's Terrace, Birkenhead.
Fielding, Edward, Esq., 142, St. Paul's Road, Camden Square, N.W.
Fisher, Rev. Osmond, M.A., F.G.S., Harlston Rectory, Cambridge.
Fletcher, T. W., Esq., M.A., F.R.S., G.S., S.A., Lawneswood House, Stourbridge.
Flower, J. W., Esq., F.G.S., Park Hill, Croydon, S.
Forbes, John Edward, F.G.S., 3, Faulkner Street, Manchester.
Fotherby, H. J., M.D., 40, Trinity Square, Tower, E.C.
Fox, Rev. W. Darwin, Delamere Rectory, near Chester.
Fraser, John, M.D., Wolverhampton.
Friedländer, Messrs., *Local Secretaries*, Berlin.
Froggat, John, Esq., Church Gate, Stockport.
Fryer, A., Esq., Chatteris, Cambridgeshire.
Fuge, J. H., Esq., F.R.C.S.E., 16, Frankfort Street, Plymouth.

Galton, Captain Douglas, R.E., F.R.S., G.S., &c., 12, Chester Street, Grosvenor Place, S.W.
Gardner, J. S., Esq., F.G.S., Park House, St. John's Wood Park, N.W.
Gassiot, I. P., Esq., F.R.S., &c., Clapham, S.
Gatty, Charles, Esq., F.G.S., Felbridge Park, East Grinstead.
Geological and Polytechnic Society of the West Riding of Yorkshire, Leeds.
Geological Society of Manchester.
Geological Survey of Great Britain, Palæontological Department, Jermyn Street, S.W.
Geologists' Association, University College, W.C.
Gibson, G. S., Esq., Saffron Walden.
Gibson, Thomas F., Esq., F.G.S., &c., Broadwater Down, Tunbridge Wells.
Gilbertson, Henry, Esq., Hertford.
Gilchrist, J., M.D., Crichton Royal Institution, Dumfries.
Glasgow Geological Society, Andersonian University, Glasgow.
Gloucester Literary Society, Gloucester (by Dr. B. Wagbourn).
Godlee, Rickman, Esq., Lillies, Upton, Essex.
Godwin-Austen, R. A. C., Esq., F.R.S., G.S., &c., *Local Secretary*, Chilworth Manor, Guildford, Surrey.
Gordon, P. L., Esq., Craigmyle.
Gough, Capt. the Hon. George S., F.G.S., L.S., &c., Lough Cutra Castle, Gort, Galway, Ireland.
Gough, Thomas, Esq., *Local Secretary*, Kendal.
Gould, John, Esq., F.R.S., L.S., Z.S., &c., 26, Charlotte Street, Bedford Square, W.C.
Gray, John, Esq., Lyttleton Terrace, Hagley, near Stourbridge.
Greenwell, G. C., Esq., Poynton, Stockport.
Gregory, J. R., Esq., 15, Russell Street, Covent Garden, W.C.
Griffith, Sir Richard, Bart., LL.D., F.R.S.E., G.S., &c., 2, Fitzwilliam Place, Dublin.
Grindrod, R. B., M.D., F.G.S., Townshend House, Great Malvern.
Grundy, Thomas, Esq., Beatlands, Sidmouth, Devon.
Guise, Sir W. V., Bart., F.G.S., &c., Elmore Court, near Gloucester.
Gunn, Rev. J., M.A., *Local Secretary*, Irstead Rectory, Norwich.
Guppy, R. Lechmere, Esq., F.G.S., Government House, Trinidad.

Hall, Hugh F., Esq., F.G.S., 17, Dale Street, Liverpool.

Hall, Townshend M., Esq., F.G.S., Pilton Parsonage, Barnstaple.
Harford, Frederick, Esq., Ocean Marine Insurance Company, 2, Old Broad Street, E.C.
Harkness, Professor Robert, F.R.S., G.S., Queen's College, Cork.
Harris, W., Esq., F.G.S., Charing, Ashford, Kent.
Harrison, William, Esq., F.G.S., S.A., R.G.S., R.S. Ant., &c., *Local Secretary*, Samlesbury Hall, Preston, Lancashire; and Conservative Club, St. James's Street, S.W.
Hartley Institution, Southampton (by Dr. F. T. Bond).
Haughton, Rev. Professor S., M.D., F.R.S., G.S., Fellow of Trinity College, Dublin.
Hawkes, Rev. Henry, B.A., F.L.S., &c., 5, Elm Grove, Southsea, Portsmouth.
Hawkins, B. Waterhouse, Esq., F.L.S., G.S., *Local Secretary*, New York.
Hawkins, Rev. H. S., Forest Lodge, Liphook, Hants.
Hawkshaw, J. Clarke, Esq., 25, Cornwall Gardens, South Kensington, W.
Haythornthwaite, William, Esq., Kirkby Lonsdale.
Heywood, James, Esq., F.R.S., G.S., &c., Athenæum Club, S.W.
Hicks, Henry, Esq., St. David's, Pembrokeshire.
Higgins, E. T., Esq., 122, King Henry's Road, Haverstock Hill, N.W.
Hindson, Isaac, Esq., Kirkby Lonsdale.
Hirst, John, jun., Esq., Dobcross, Saddleworth, near Manchester.
Hodgson, Miss E., Cavendish Street, Ulverstone.
Holden, Adam, Esq., 48, Church Street, Liverpool.
Hony, Rev. W. E., F.G.S., &c., Archdeacon of Sarum, Beverstock, near Salisbury.
Hopgood, James, Esq., Clapham Common, S.W.
Horen, Dr. F. Van, St. Trond, Belgium.
Horner, Rev. John S., Mells Park, near Frome.
Howitt, Thomas, Esq., Queen Square, Lancaster.
Huddersfield Literary and Scientific Society.
Hughes, T. M'K., Esq., B.A., F.G.S., Museum of Practical Geology, Jermyn Street, S.W.
Hudson, Robert, Esq., F.R.S., G.S., Clapham, S.W.
Hull, W. D., Esq., F.G.S., &c., 36, Queen's-Gate Terrace, South Kensington.
Hunter, J. R. S., Esq., Braidwood, Carluke, N.B.
Hutton, R., Esq., F.G.S., M.R.I.A., &c., Putney Park, S.W.
Huxley, Professor T. H., LL.D., Ph.D., F.R.S., L.S., G.S., Museum of Practical Geology Jermyn Street, S.W.

Illingworth, R. S., Esq., 9, Norfolk Crescent, W.
Ilott, James William, Esq., Bromley, Kent.
Ipswich Museum, Ipswich.

J'Anson, E., Esq., 7A, Laurence Pountney Hill, E.C.
James, Colonel Sir H., R.E., F.R.S., G.S., &c., Ordnance Survey, Southampton.
Jarvis, Richard H., Esq., F.G.S., Beckenham, Kent, S.E.
Jeffreys, J. Gwyn, Esq., F.R.S., L.S., G.S., 25, Devonshire Place, Portland Place, W.
Johnes, J., Esq., F.G.S., Dolancothy, Llandilo, Wales.
Johnson, William, Esq., Eton College.
Jones, John, Esq., Newport Road, Middlesborough.
Jordan, Swifen, Esq., Cherith Lodge, Clifton Park, Bristol.

Jukes, J. Beete, Esq., M.A., F.R.S., F.G.S., &c., Geological Survey of Ireland, 51, Stephen's Green, Dublin.
Judd, J. W., Esq., F.G.S., Museum of Practical Geology, Jermyn Street, S.W.

Kenyon, the Hon. Mrs. Thomas, Pradoe, near Shrewsbury.
King, W. P., Esq., Avonside, Clifton Down, Bristol.
Kinnaird, Lord, Rossie Priory, Inchture, N.B.
Kingston, G. S., Esq., Grote Street, Adelaide, South Australia.
Knight, Captain E., Hornacott Manor, Launceston.
Krantz, Herr, Bonn.

Lawrance, John, Esq., F.G.S., Elton, Oundle.
Leckenby, John, Esq., F.G.S., *Local Secretary*, Scarborough.
Lee, Henry, Esq., F.L.S., G.S., The Waldrons, Croydon, S.
Lee, John Edward, Esq., F.G.S., The Priory, Caerleon, Monmouthshire.
Leeds, E. C., Esq., B.A., Eyebury, Peterboro'.
Leeds Library, Leeds, Yorkshire.
Leicester Literary and Philosophical Society, Town Museum, Leicester.
Leighton, W. H., Esq., 2, Merton Place, Turnham Green, W.
Leonard, Edward J., Esq., Engineer's Office, West India Docks, E.
Lightbody, Robert, Esq., Ludlow.
Lindsay, Charles, Esq., Ridge Park, Lanark, N.B.
Lingard, John R., Esq., 10, Booth Street, Piccadilly, Manchester.
Linnean Society, Burlington House, Piccadilly, W.
Lister, J. J., Esq., F.R.S., &c., Upton, Essex.
Literary and Philosophical Society of Manchester.
Literary and Philosophical Society of Newcastle, Westgate Street, Newcastle-on-Tyne.
Literary and Philosophical Society of Sheffield (by J. Holland, Esq., Music Hall, Sheffield).
Liveing, Professor G. D., M.A., St. John's College, Cambridge.
Liverpool Free Public Library.
Liverpool Natural History Society.
Lloyd, J. H., Esq., 10, Lancaster Gate, W.
Lobley, J. L., Esq., 50, Lansdowne Road, Kensington Park, W.
London Institution, Finsbury Circus, E.C.
Lovèn, Professor S., Stockholm.
Lubbock, Sir John W., Bart., M.A., F.R.S., L.S., 15, Lombard Street, E.C.
Lucas, Joseph, jun., Esq., Upper Tooting, Surrey.
Lucas, John F., Esq., Middleton, Yolgrave, Bakewell, Derbyshire.
Ludlow Natural History Society.
Lyall, George, Esq., F.G.S., 38, Winchester Street, South Shields.
Lyell, Sir C., Bart., M.A., F.R.S., L.S., G.S., &c., 72, Harley Street, Cavendish Square, W.
Lyon, Bibliothèque de la Ville de.

McAndrew, R., Esq., F.R.S., Bond Street Chambers, Walbrook, E.C.
McCollough, D.M., M.D., Larchfield, Abergavenny.

Mackeson, Henry B., Esq., F.G.S., &c., Hythe, Kent.
Mackey, Colonel, Fairhill, near Exeter.
Maclean, William C., Esq., 5, Camperdown Terrace, Great Yarmouth.
Macmillan, Messrs., Cambridge.
McMorran, A., Esq., Cheapside, E.C.
Macredie, P. B. M., Esq., Perceton House, Irvine, N.B.
Madras Government Museum (per Messrs. Williams and Norgate).
Major, Charles, Esq., Red Lion Wharf, Upper Thames Street, E.C.
Mann, C. S., Esq., F.G.S., Eltham, Kent, S.E.
Mansel, John, Esq., F.G.S., Longthorns, Blandford, Dorset.
Manzoni, Dr. Angelo, Ravenia.
Marès, Mons. P., Paris.
Marshall, James G., Esq., F.G.S., Headingley, near Leeds.
Marshall, Matthew, Esq., Bank of England, E.C.
Marshall, Reginald D., Esq., Cookridge Hall, Leeds.
Marsham, Hon. Robert, F.G.S., 5, Chesterfield Street, Mayfair, W.
Martin, Miss, Bredon's Norton, near Tewkesbury.
Mathews, W., jun., Esq., F.G.S., *Local Secretary*, 5, Carpenter Road, Edgbaston, Birmingham.
Maton, Professor B.
Matthieson, James, Esq., 22, Belitha Villas, Barnsbury Park, N.
Maw, G., Esq., F.S.A., L.S., G.S., Benthall Hall, Broseley, Salop.
Meade, Rev. R. J., Castle Cary.
Merian, Professor Dr. Pierre, F.M.G.S., Directeur du Muséum, Basle.
Meryon, Edward, M.D., F.G.S., 14, Clarges Street, W.
Millar, John, M.D., F.L.S., G.S., Bethnall House, Cambridge Road, N.E.
Milne-Edwards, Dr. Henry, F.M.G.S., Paris.
Mitchell, F. J., Esq., Llanbrechba Grange, Newport, Monmouthshire.
Mitchell, W. S., Esq., LL.B., F.L.S., G.S., New University Club, St. James's Street, S.W.
Mitchenson, Rev. John, D.C.L., King's School, Canterbury.
Möller, Captain Valerian, Institut des Mines, St. Petersburg.
Monk, James, Esq., Aden Cottage, Durham.
Moore, J. Carrick, Esq., M.A., F.R.S., G.S., &c., 113, Eaton Square, S.W.
Moore, Charles, Esq., F.G.S., 6, Cambridge Place, Widcome Hill, Bath.
Moore, Joseph, Esq., Grasmere Lodge, Lower Tulse Hill, S.
Morgan, William, Esq., Bryn Nant, Swansea.
Morton, George Highfield, Esq., F.G.S., *Local Secretary*, 5, London Road, Liverpool.
Mosley, Sir Oswald, Bart., D.C.L., F.L.S., G.S., &c., Rolleston Hall, Burton-on-Trent.
Murchison, Sir R. I., Bart., K.C.B., G.C.St.S., D.C.L., M.A., F.R.S., G.S., L.S., &c., *Vice President*, 16, Belgrave Square, S.W.
Murdock, James Barclay, Esq., 33, Lynedoch Street, Glasgow.
Museum of Practical Geology, Jermyn Street, S.W.
Mushet, Robert, Esq., F.G.S., Royal Mint, Little Tower Hill, E.

Nantes, Musée d'Histoire Naturelle de.
Neale, Edward Vansittart, Esq., West Wickham, Kent.
Nicholl, W. A., Esq., Ham Court, Glamorganshire.
Norfolk and Norwich Literary Institution, Norwich.
Nottingham Literary and Philosophical Society, School of Art, Nottingham.

Nunneley, Thomas, Esq., *Local Secretary*, 22, Park Place, Leeds.
Nutt, D., Esq.. Strand, W.C.

Oldham, Mrs., Hyde House, South Littleton, Eversham, Worcestershire.
Oñate, Countess of, Madrid.
Oswestry Naturalists' Field Club, Oswestry.
Ormerod, G. W., Esq., M.A., F.G.S., &c., Brookbank, Teignmouth.
Owen, Professor R., M.D., LL.D., F.R.S., L.S., G.S., &c., *Vice-President*, British Museum, W.C.

Paine, Mrs. J. M., Farnham, Surrey.
Papillon, Rev. J., Rectory, Lexden, Colchester.
Parker, J., Esq., F.G.S., Turl Street, Oxford.
Parry, Thomas G., Esq., F.G.S., Highnam Court, near Gloucester.
Pattison, S. R., Esq., F.G.S., 50, Lombard Street, E.C.
Paynter, Rev. Samuel, Stoke Hill, Guildford, Surrey.
Peabody Institution, America.
Pearson, Sir Edwin, K.H., M.A., F.R.S., &c., Wimbledon, S.W
Pease, Thomas, Esq., F.G.S., Cote Bank, Westbury-on-Trym, Bristol.
Peckover, Algernon, Esq., F.L.S., Wisbeach.
Pengelly, William, Esq., F.R.S., G.S., *Local Secretary*, Torquay.
Penny, Rev. James, M.A., &c., Blandford.
Penruddocke, Charles, Esq., Compton Park, near Salisbury.
Perceval, Spencer George, Esq., Severn House, Henbury, Bristol.
Perkins, Rev. R. B., Wootton-Underedge, Gloucestershire.
Phillips, John, M.A., LL.D., F.R.S., G.S., &c., Professor of Geology in the University of Oxford, *Vice-President*, Museum, Oxford.
Philosophical Society of Glasgow.
Phear, Rev. George, F.G.S., Emmanuel College, Cambridge.
Phené, John S., Esq., 34, Oakley Street, Chelsea, S.W.
Pickering, John, Esq., 29, Loraine Road, Upper Holloway, N.
Pictet, Mons. F. J., Professor of Zoology, Academy of Geneva.
Pidgeon, Jonathan S., Esq., Pembridge Villa, Bayswater, W.
Plant, James, Esq., *Local Secretary*, 40, West Terrace, West Street, Leicester.
Pollock, Lady, Clapham Common, S.W.
Portal, Wyndham S., Esq., Malshanger House, Basingstoke.
Portman, Hon. Miss, 5, Princes Gate, Hyde Park, S.W.
Poynton, Rev. Francis, Rectory, Kelston, Bath.
Prestwich, Joseph, Esq., F.R.S., G.S., Shoreham, Sevenoaks.
Prout, Rev. E., F.G.S., &c., Fairfield, Torquay.
Powrie, James, Esq., F.G.S., Reswallie, Forfar.
Provis, William A., Esq., F.G.S., The Grange, Ellesmere, Salop.
Puxty, C., Esq., Maldon, Essex.

Quaritch, B., Esq., Piccadilly, W.
Queen's College, Cork (by Messrs. Hodges and Smith).

Queen's College, Galway.
Queen's College, Oxford.

Raban, Capt. R. B., Shirehampton, Bristol.
Radcliffe Library, Oxford.
Ramsay, Mrs. Wm., Rannagubzion, Blairgowrie.
Ramsay, Professor A. C., LL.D., F.R.S., G.S., &c., Museum Pract. Geology, Jermyn Street, S.W.
Ransome, Robert Charles, Esq., Ipswich.
Regnès, Mons., Paris.
Renevier, Mons. E., Professor of Geology, Academy of Lausanne, Switzerland.
Richardson, James, Esq., Glaurafon, Swansea.
Richardson, William, Esq., High Field, Southouram, near Halifax.
Ricketts, Charles, M.D., F.G.S., 22, Argyle Street, Birkenhead.
Ripon Scientific Society.
Risley, Rev. William Cotton, M.A., Deddington, Oxfordshire.
Robertson, E. H., Fair Ville, Rose Mount, Oxton, Cheshire.
Robbins, George, Esq., F.G.S., 9, Royal Crescent, Bath.
Rofe, John, Esq., F.G.S., &c., 7, Queen Street, Lancaster.
Roper, F. C. S., Esq., F.G.S., L.S., 157, Maida Vale, W.
Rose, C. B., Esq., F.G.S., &c., 28, King Street, Great Yarmouth.
Rothery, H. C., Esq., M.A., F.L.S., 94, Gloucester Terrace, Hyde Park W.
Rothery, Charles W., Esq., Greta Hall, Keswick.
Royal Artillery Institution, Woolwich, S.E.
Royal College of Science for Ireland, Stephen's Green, Dublin.
Royal College of Surgeons, Lincoln's Inn Fields, W.C.
Royal Dublin Society, Dublin.
Royal Geological Society of Cornwall, Penzance.
Royal Institution of Cornwall, Truro.
Royal Institution of Great Britain, Albemarle Street, W.
Royal Institution, Liverpool.
Royal Institution of South Wales, Swansea.
Royal Irish Academy, 19, Dawson Street, Dublin.
Royal Society of Edinburgh.
Royal Society of London, Burlington House, W.
Rudd, Rev. Leonard H., M.A., Kempsey, Worcester.
Rutter, John, Esq., Ilminster.
Rylands, T. G., Esq., F.L.S., G.S., Heath House, Warrington.

Sabine, General, R.A., F.R.S., L.S., &c., 13, Ashley Place, Westminster, S.W.
Salford Borough Royal Museum and Library, Peel Park.
Salt, S., Esq., Ulverstone.
Sanders, Gilbert, Esq., M.R.I.A., &c., 53, Claverton Street, S.W.
Sanders, W., Esq., F.R.S., G.S., &c., *Local Secretary*, 21, Richmond Terrace, Clifton, Bristol.
Sanford, W. A., Esq., F.G.S., Nynehead Court, Wellington, Somerset.
Saul, G. T., Esq., F.Z.S., Bow Lodge, Bow Road, E.
Saunders, James Ebenezer, Esq., F.L.S., G.S., 9, Finsbury Circus, E.C.

Saunders, W. Wilson, Esq., F.R.S., L.S., &c., Lloyd's, E.C.
Savy, Mons. F., *Local Secretary*, 24, Rue Hautefeuille, Paris.
Scarborough Philosophical Society.
Sedgwick, Rev. Adam, M.A., F.R.S., G.S., &c., Cambridge.
Severs, J., Esq., Airthwaite, Kendal.
Sharman, George, Esq., 9, St. George's Road, Kilburn.
Sharp, John, Esq., F.G.S., *Local Secretary*, Culverden Hill, Tunbridge Wells, Kent.
Sharp, Samuel, Esq., F.G.S., S.A., Dallington Hall, Northampton.
Shaw, John, M.D., F.G.S., &c., Hop House, Boston, Lincolnshire.
Sheppard, T. Byard, Esq., Selwood Cottage, Frome.
Sheppard, Alfred B., Esq., Torquay.
Sidney Sussex College Library, Cambridge.
Simpson, J. B., Esq., Hedgefield House, Blaydon-on-Tyne.
Skaife, John, Esq., 6, Union Street, Blackburn.
Sloper, G. E., Esq., Devizes.
Smith, Rev. Charles Lesingham, Little Canfield Rectory, near Chelmsford, Essex.
Smith, Captain Robert, Frankford Avenue, Rathgar, Dublin.
Smith, Rev. Urban, Stoney Middleton.
Smithe, J. D., Esq., C.E., F.G.S., Madhopoor, Punjâb (by Messrs. Smith, Elder, and Co.).
St. Peter's College, Cambridge.
Somersetshire Archæological and Natural History Society, Museum, Taunton.
Sopwith, T., Esq., F.R.S., G.S., 103, Victoria Street, S.W.
South Shields Geological Club.
Sowerby, James de Carle, Esq., F.L.S., &c., Royal Botanic Gardens, Regent's Park, N.W.
Spicer, Henry, Esq., jun., 19, New Bridge Street, Blackfriars, E.C.
Spink, J., Esq., Drax, Selby.
Spragge, W. Kennaway, Esq., the Quarry, Paignton, South Devon.
Stebbing, Rev. T. R. R., M.A., Tor Crest Hall, Torquay.
Steedman, John, Esq., Charlestown by Dunfermline.
Stewart, Mrs. John, 7, Grosvenor Crescent, Edinburgh.
Stobart, W. C., Esq., Etherley House, Darlington.
Stoddart, W. W., Esq., F.G.S., 9, North Street, Bristol.
Stubbs, Charles E., Esq., Henley-on-Thames.
Studer, Herr B., For.M.G.S., Professor of Geology, Berne.
Sunderland Corporation Museum.
Sunderland Geological Society.
Sunderland Subscription Library.
Swayne, H. J. F., Esq., The Island, Wilton, Wilts.

Tate, Geo., Esq., F.G.S., Alnwick, N.B.
Tawney, E. B., Esq., F.G.S., Woodville, Ilfracombe, N. Devon.
Taylor, S. Watson, Esq., Erlestoke Park, Devizes.
Tennant, Professor Jas., F.G.S., &c., 149, Strand, W.C. (*Two Copies.*)
Teuchner, Professor.
The General Administration of Mines and Salt-works in Munich (by Messrs. Williams and Norgate).
Thomas, Capt. F. W. L., R.N., H.M.S. "Woodlark," Trinity, near Edinburgh.
Thompson, Miss S., Stamford.

Thompson, Thomas, Esq., Hull.
Thomson, Alexander, Esq., F.R.S.E., Banchory House, Aberdeen.
Thomson, Professor Wyville, LL.D., F.G.S., Queen's College, Belfast.
Tomes, John, Esq., 37, Cavendish Square, W.
Torquay Natural History Society.
Traquair, Professor R. H., M.D., Royal Agricultural College, Cirencester.
Trautschold, Dr., Moscow.
Trevelyan, Sir W. C., Bart., F.G.S., Wellington, Newcastle-on-Tyne ; and Athenæum Club, S.W.
Trinity College, Cambridge.
Turner, E. J., Esq., Fairlight Villas, Clapham, S.
Twamley, Charles, Esq., F.G.S., 6, Queen's Road, Gloucester Gate, Regent's Park, N.W.
Tyler, Chas., Esq., F.L.S., G.S., 24, Holloway Place, Holloway, N.
Tylor, Alfred, Esq., F.L.S., G.S., Warwick Lane, Newgate Street, E.C.

University of Edinburgh.
University of Glasgow.
University Library, Aberdeen.
University Library, Leipzig.
University Library, St. Andrew's.

Verneuil, Mons. Edouard de, Mem. de l'Instit., F.M.G.S., 57, Rue de la Madeleine, Paris.
Vernon Park Museum, Stockport.
Vicary, William, Esq., F.G.S., The Priory, Colleton Crescent, Exeter.

Wall, Geo. P., Esq., F.G.S., Pitmoor, near Sheffield.
Walmstedt, Dr. L. P., Professor of Mineralogy, Upsala.
Walton, William, Esq., 11, Paragon, Blackheath, S.E.
Walton, William, Esq., *Local Secretary*, 17, Grosvenor Place, Bath.
Ward, Henry, Esq., F.G.S., Oaklands, Wolverhampton.
Wardle, Thos., Esq., F.G.S., St. Edward Street, Leek.
Waring, Samuel Long, Esq., F.G.S., The Oaks, Norwood, Surrey, S.
Warrington Museum and Library.
Warwickshire Natural History Society, Warwick.
Watson, Rev. R. B., F.G.S., 4, Bruntsfield Place, Edinburgh.
West, G. Herbert, Esq., B.A., F.G.S., 61, Wimpole Street, W.
Wetherell, N. T., Esq., F.G.S., &c., Highgate, N.
White, Alfred, Esq., F.L.S., &c., Castle Street, Cow Cross, E.C.
Willaume, T. B. T., Esq., jun., 24, Chester Terrace, Regent's Park.
Willcock, J. W., Esq., 6, Stone Buildings, Lincoln's Inn, W.C.
Williams and Norgate, Messrs., Henrietta Street, Covent Garden, W.C.
Willis and Sotheran, Messrs., Strand, W.C.
Wilson, J. M., Esq., B.A., F.G.S., Rugby.
Wilson, Rev. Dr. W., Southampton.
Wiltshire, Rev. Thomas, M.A., F.L.S., G.S., &c., *Honorary Secretary*, 13, Granville Park, Lewisham, Kent, S.E.

Winstone, Benjamin, M.D., 7, Ely Place, Holborn, E.C.
Witts, Rev. E. F., F.G.S., Rectory, Upper Slaughter, near Stow-on-the-Wold.
Winwood, Rev. Henry H., F.G.S., 4, Cavendish Crescent, Bath.
Wolley-Dod, Rev. Charles, Eton College.
Wood, Edward, Esq., F.G.S., R.S.L., &c., *Local Secretary*, Richmond, Yorkshire.
Wood, Henry, Esq., 10, Cleveland Square, Bayswater, W.
Wood, Rev. Henry H., F.G.S., Holwell Rectory, Sherborne, Dorset.
Wood, Rev. J. E. Tenison, F.G.S., Penola, South Australia.
Wood, S. V., Esq., F.G.S., &c., *Treasurer*, Brentwood, Essex.
Woodall, Major J. W., M.A., F.G.S., &c., St. Nicholas House, Scarborough.
Woodd, C. H. L., Esq., F.G.S., S.A., &c., Hillfield, Hampstead, N.W.
Woodward, Charles, Esq., F.R.S., 10, Compton Terrace, Islington, N.
Woodward, Henry, Esq., F.G.S., Z.S., British Museum, W.C.
Worcestershire Natural History Society, Foregate, Worcester.
Wright, F. Beresford, Esq., Aldercar Hill, Langley Mill, Derbyshire.
Wright, Joseph, Esq., F.G.S., 7, Donegall Street, Belfast.
Wright, Thomas, M.D., F.R.S.E., G.S., *Local Secretary*, St. Margaret's Terrace, Cheltenham.
Wurzburg, the Royal University Library of.

Yates, James, Esq., M.A., F.R.S., L.S., G.S., Lauderdale House, Highgate, N.
Yorkshire Naturalists' Club, York (by Ed. Smallwood, Esq.).
Yorkshire Philosophical Society, York.
Young, James, Esq., Burr Street, Tower Hill, E.

Zoological Society of London, 11, Hanover Square, W.

CATALOGUE OF WORKS

ALREADY PUBLISHED BY

THE PALÆONTOGRAPHICAL SOCIETY:

Showing the ORDER *of publication; the* YEARS *during which the Society has been in operation; and the* CONTENTS *of each yearly Volume.*

Vol. I. Issued for the Year	1847	The Crag Mollusca, Part I, Univalves, by Mr. S. V. Wood, 21 plates.
,, II. ,,	1848	The Reptilia of the London Clay, Part I, Chelonia, &c., by Profs. Owen and Bell, 38 plates. The Eocene Mollusca, Part I, Cephalopoda, by Mr. F. E. Edwards, 9 plates.
,, III.	1849	The Entomostraca of the Cretaceous Formations, by Mr. T. R. Jones, 7 plates. The Permian Fossils, by Prof. Wm. King, 29 plates. The Reptilia of the London Clay, Part II, Crocodilia and Ophidia, &c., by Prof. Owen, 18 plates. The Fossil Corals, Part I, Crag, London Clay, Cretaceous, by Messrs. Milne-Edwards and Jules Haime, 11 plates.
IV ,,	1850	The Crag Mollusca, Part II, No. 1, by Mr. S. V. Wood, 12 plates. The Mollusca of the Great Oolite, Part I, Univalves, by Messrs. Morris and Lycett, 15 plates. The Fossil Brachiopoda, Part III, No. 1, Oolitic and Liassic, by Mr. Davidson, 13 plates.
,, V. ,,	1851	The Reptilia of the Cretaceous Formations, by Prof. Owen, 39 plates. The Fossil Corals, Part II, Oolitic, by Messrs. Milne-Edwards and Jules Haime, 19 plates. The Fossil Lepadidæ, by Mr. Charles Darwin, 5 plates.

CATALOGUE OF WORKS—Continued.

Vol. VI	Issued for the Year 1852	The Fossil Corals, Part III, Permian and Mountain-limestone, by Messrs. Milne-Edwards and Jules Haime, 16 plates. The Fossil Brachiopoda, Part I, Tertiary, by Mr. Davidson, 2 plates. The Fossil Brachiopoda, Part II, No. 1, Cretaceous, by Mr. Davidson, 5 plates. The Fossil Brachiopoda, Part III, No. 2, Oolitic and Liassic, by Mr. Davidson, 5 plates. The Eocene Mollusca, Part II, Pulmonata, by Mr. F. E. Edwards, 6 plates. The Radiaria of the Crag, London Clay, &c., by Prof. E. Forbes, 4 plates.
„ VII	1853	The Fossil Corals, Part IV, Devonian, by Messrs. Milne-Edwards and Jules Haime, 10 plates. The Fossil Brachiopoda, Introduction to Vol. I, by Mr. Davidson, 9 plates. The Mollusca of the Chalk, Part I, Cephalopoda, by Mr. D. Sharpe, 10 plates. The Mollusca of the Great Oolite, Part II, Bivalves, by Messrs. Morris and Lycett, 8 plates. The Mollusca of the Crag, Part II, No. 2, Bivalves, by Mr. S. V. Wood, 8 plates. The Reptilia of the Wealden Formations, Part I, Chelonia, by Prof. Owen, 9 plates.
„ VIII.	*1854	The Fossil Brachiopoda, Part II, No. 2, Cretaceous, by Mr. Davidson, 8 plates. The Reptilia of the Wealden Formations, Part II, Dinosauria, by Prof. Owen, 20 plates. The Mollusca of the Great Oolite, Part III, Bivalves, by Messrs. Morris and Lycett, 7 plates. The Fossil Corals, Part V, Silurian, by Messrs. Milne-Edwards and Jules Haime, 16 plates. The Fossil Balanidæ and Verrucidæ, by Mr. Charles Darwin, 2 plates. The Mollusca of the Chalk, Part II, Cephalopoda, by Mr. D. Sharpe, 6 plates. The Eocene Mollusca, Part III, No. 1, Prosobranchiata, by Mr. F. E. Edwards, 8 plates.
„ IX	†1855	The Mollusca of the Crag, Part II, No. 3, Bivalves, by Mr. S. V. Wood, 11 plates. The Reptilia of the Wealden Formations, Part III, by Prof. Owen, 12 plates. The Eocene Mollusca, Part III, No. 2, Prosobranchiata, continued, by Mr. F. E. Edwards, 4 plates. The Mollusca of the Chalk, Part III, Cephalopoda, by Mr. D. Sharpe, 11 plates. The Tertiary Entomostraca, by Mr. T. R. Jones, 6 plates. The Fossil Echinodermata, Part I, Oolitic, by Dr. Wright, 10 plates.
„ X	1856	The Fossil Echinodermata, Part II, Oolitic, by Dr. Wright, 12 plates. The Fossil Crustacea, Part I, London Clay, by Prof. Bell, 11 plates. The Fossil Brachiopoda, Part IV, Permian, by Mr. Davidson, 4 plates. The Fossil Brachiopoda, Part V, No. 1, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Wealden Formations, Part IV, by Prof. Owen, 11 plates. The Reptilia of the London Clay (Supplement), by Prof. Owen, 2 plates.

* This Vol. is marked on the outside 1855.

† This Vol. is marked on the outside 1856.

CATALOGUE OF WORKS—Continued.

Vol. XI. Issued for the Year	1857	The Fossil Echinodermata, Part III, Oolitic, by Dr. Wright, 14 plates. The Fossil Brachiopoda, Part V, No. 2, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Cretaceous Formations (Supplement I), by Prof. Owen, 4 plates. The Reptilia of the Wealden Formations (Supplement No. 2), by Prof. Owen, 8 plates. The Polyzoa of the Crag, by Prof. Busk, 22 plates.
,, XII. ,,	1858	The Fossil Echinodermata, Part IV, Oolitic, by Dr. Wright, 7 plates. The Eocene Mollusca, Part III, No. 3, Prosobranchiata continued, by Mr. F. E. Edwards, 6 plates. The Reptilia of the Cretaceous Formations (Supplements No. 2, No. 3), by Prof. Owen, 7 plates. The Reptilia of the Purbeck Limestones, by Prof. Owen, 1 plate. The Fossil Brachiopoda, Part V, No. 3, Carboniferous, by Mr. Davidson, 10 plates.
, XIII. ,,	1859	The Fossil Brachiopoda, Part V, No. 4, Carboniferous, by Mr. Davidson, 20 plates. The Reptilia of the Oolitic Formations, No. 1, Lower Lias, by Prof. Owen, 6 plates. The Reptilia of the Kimmeridge Clay, No. 1, by Prof. Owen, 1 plate. The Eocene Mollusca, Part IV, No. 1, Bivalves, by Mr. S. V. Wood, 13 plates.
, XIV. ,,	1860	The Fossil Brachiopoda, Part V, No. 5, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Oolitic Formation, No. 2, Lower Lias, by Prof. Owen, 11 plates. The Reptilia of the Kimmeridge Clay, No. 2, by Prof. Owen, 1 plate. The Fossil Estheriæ, by Prof. Rupert Jones, 5 plates. The Fossil Crustacea, Part II, Gault and Greensand, by Prof. Bell, 11 plates.
,, XV. ,,	1861	The Fossil Echinodermata, Vol. II, Part I (Oolitic Asteroidea), by Dr. Wright, 13 plates. Supplement to the Great Oolite Mollusca, by Dr. Lycett, 15 plates.
,, XVI. ,,	1862	The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part I, by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VI, No. 1, Devonian, by Mr. Davidson, 9 plates. The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood, 7 plates. The Reptilia of the Cretaceous and Wealden Formations (Supplements), by Prof. Owen, 10 plates.
, XVII. ,,	1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W. Salter, 8 plates. The Fossil Brachiopoda, Part VI, No. 2, Devonian, by Mr. Davidson, 11 plates. The Belemnitidæ, Part I, Introduction, by Prof. Phillips. The Reptilia of the Liassic Formations, Part I, by Prof. Owen, 16 plates.

CATALOGUE OF WORKS—Continued.

Vol. XVIII. Issued for the Year	1864	The Fossil Echinodermata, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright, plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W Salter, 11 plates. The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips, 7 plates. The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford, 5 plates. Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous and Wealden Formations.
,, XIX.* ..	1865	The Crag Foraminifera, Part I, No. 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, 4 plates. Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan, 10 plates. The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward, 9 plates. The Fossil Brachiopoda, Part VII, No. 1, Silurian, by Mr. Davidson, 12 plates.
,, XX.* ..	1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VII, No. 2, Silurian, by Mr. Davidson, 10 plates. The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips, 13 plates.
.. XXI.* ..	1867	Flora of Carboniferous Strata, Part I, by Mr. E. W. Binney, 6 plates. Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright, 14 plates. The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. R. Lankester, 5 plates. The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford, 14 plates.
,, XXII.* ..	1868	Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan, 9 plates. The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward, 6 plates. The Fossil Brachiopoda, Part VII, No. 3, Silurian, by Mr. Davidson, 15 plates. The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips, 7 plates. The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen, 4 plates. The Pleistocene Mammalia, Part III, Felis spelæa, continued, with F. Lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford, 6 plates.
.. XXIII.* ..	1869	Supplement to the Fossil Corals, Part II, No. 2, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part III, by Dr. Wright, 10 plates. The Belemnitidæ, Part V, Oxford Clay, &c., Belemnites, by Prof. Phillips, 9 plates. The Fishes of the Old Red Sandstone, Part I (concluded), by Messrs. J. Powrie and E. Ray Lankester, 9 plates. The Reptilia of the Liassic Formations, Part II, by Prof. Owen, 4 plates. The Crag Cetacea, No. 1, by Prof. Owen, 5 plates.

* These Volumes are issued in two forms of binding, first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous volumes are not in separate parts.

LIST OF MONOGRAPHS

Completed, in course of Publication, and in Preparation.

MONOGRAPHS which have been COMPLETED :—

The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime.
The Polyzoa of the Crag, by Mr. G. Busk.
The Tertiary Echinodermata, by Professor Forbes.
The Fossil Cirripedes, by Mr. C. Darwin.
The Tertiary Entomostraca, by Prof. T. Rupert Jones.
The Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Fossil Estheriæ, by Prof. T. Rupert Jones.
The Tertiary, Cretaceous, Oolitic, Liassic, Permian, Carboniferous, and Devonian Brachiopoda, by Mr. T. Davidson.
The Mollusca of the Crag, by Mr. S. V. Wood.
The Great Oolite Mollusca, by Professor Morris and Mr. J. Lycett.
The Cretaceous (Upper) Cephalopoda, by Mr. D. Sharpe.
The Fossils of the Permian Formation, by Professor King.
The Reptilia of the London Clay (and of the Bracklesham and other Tertiary Beds), by Professors Owen and Bell.
The Reptilia of the Cretaceous, Wealden, and Purbeck Formations, by Professor Owen.

MONOGRAPHS in course of PUBLICATION :*—

The Flora of the Carboniferous Formation, by Mr. E. W. Binney.
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
Supplement to the Fossil Corals, by Dr. Duncan.
The Echinodermata of the Oolitic and Cretaceous Formations, by Dr. Wright.
The Fossil Merostomata, by Mr. H. Woodward.

* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

MONOGRAPHS in course of PUBLICATION—*Continued.*

The Trilobites of the Mountain-Limestone, Devonian, and Silurian Formations, by Mr. J. W. Salter.*
The Malacostracous Crustacea, by Professor Bell.
The Eocene Mollusca, by Messrs. F. E. Edwards and S. V. Wood.
The Silurian Brachiopoda, by Mr. Davidson.
The Belemnites, by Professor Phillips.
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester.
The Reptilia of the Kimmeridge Clay, by Professor Owen.
The Reptilia of the Liassic Formations, by Professor Owen.
The Pleistocene Mammalia, by Messrs. Boyd Dawkins and W. A. Sanford.
The Cetacea of the Crag, by Professor Owen.

* Unfinished through the death of the Author.

MONOGRAPHS which are in course of PREPARATION :†—

The Flora of the Tertiary Formation, by Mr. W. S. Mitchell.
The Cretaceous Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
The Foraminifera of the Lias, by Mr. H. B. Brady.
The Graptolites, by Professor Wyville Thomson.
The Polyzoa of the Chalk Formation, by Mr. G. Busk.
The Palæozoic Polyzoa, by Dr. Duncan.
The Crinoidea, by Professor Wyville Thomson.
The Post-Tertiary Entomostraca, by the Rev. H. W. Crosskey and Messrs. G. S. Brady and D. Robertson.
The Wealden, Purbeck, and Jurassic Entomostraca, by Messrs. T. Rupert Jones and G. S. Brady.
The Bivalve Entomostraca of the Carboniferous Formations, by Messrs. T. Rupert Jones and J. W. Kirkby.
The Trigoniæ, by Dr. Lycett.
The Post-Tertiary Mollusca, by Mr. J. Gwyn Jeffreys.
The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.
The Purbeck Mollusca, by Mr. R. Etheridge.
The Inferior Oolite Mollusca, by Mr. R. Etheridge.
The Rhætic Mollusca, by Mr. R. Etheridge.
The Liassic Gasteropoda, by Mr. Ralph Tate.
The Ammonites of the Lias, by Dr. Wright.

† Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

Dates of the Issue of the Yearly Volumes of the Palæontographical Society.

The Volume for	1847	was	issued	to the Members,	March, 1848.
,,	1848	,,	,,	,,	July, 1849.
,,	1849	,,	,,	,,	August, 1850.
,,	1850	,,	,,	,,	June, 1851.
,,	1851	,,	,,	,,	June, 1851.
,,	1852	,,	,,	,,	August, 1852.
,,	1853	,,	,,	,,	December, 1853.
,,	1854	,,	,,	,,	May, 1855.
,,	1855	,,	,,	,,	February, 1857.
,,	1856	,,	,,	,,	April, 1858.
,,	1857	,,	,,	,,	November, 1859.
,,	1858	,,	,,	,,	March, 1861.
,,	1859	,,	,,	,,	December, 1861.
,,	1860	,,	,,	,,	May, 1863.
,,	1861	,,	,,	,,	May, 1863.
,,	1862	,,	,,	,,	August, 1864.
,,	1863	,,	,,	,,	June, 1865.
,,	1864	,,	,,	,,	April, 1866.
,,	1865	,,	,,	,,	December, 1866.
,,	1866	,,	,,	,,	June, 1867.
,,	1867	,,	,,	,,	June, 1868.
,,	1868	,,	,,	,,	February, 1869.
,,	1869	,,	,,	,,	January, 1870.

SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* JANUARY, 1870): *showing in the* FIRST *column whether each Monograph hitherto published be* complete, *or in the* course of completion; *in the* SECOND *column, the yearly volumes which contain each particular Monograph (as a guide to binding the same); and in the* THIRD *and following columns, the number of pages, plates, figures, and species described in the different Monographs.*

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the Volume containing the Monograph was issued.	III *m*. Dates of the Years of Publication on the title-page of each part.	IV *n*. Dates of the Years *in which* the Monograph was published.	III. No. of Pages of Letterpress in each Monograph.	IV. No. of Plates in each Monograph.	V. No. of Lithographed Figures and of Woodcuts.	VI. No. of Species described in the Text.
The Flora of the Carboniferous Strata, by Mr. E. W. Binney, in course of completion	1867	1868	1868	32	6	32	2
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, in course of completion	1865	1866	1866	78	4	211	43
Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime, *complete*(*k*)	1849, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1855	406	72	800	319*g*
Supplement to the Fossil Corals, by Dr. Duncan, in course of completion	1865, 1866, 1867, 1868, 1869	1866, 1867, 1868, 1869, 1870	1866, 1867, 1868, 1869, 1870	190	42	710	129
The Polyzoa of the Crag, by Mr. G. Busk, *complete*	1857	1859	1859	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, *complete*	1852	1852	1852	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, *complete*	1855, 1856, 1857, 1858	1855, 1856, 1859, 1860	1857, 1558, 1859, 1861	474	43	724	109*h*
,, ,, Vol. II, in course of completion	1861, 1864	1862, 1866	1863, 1866	154	19	218	29
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, in course of completion	1862, 1867, 1869	1864, 1868, 1870	1864, 1868, 1870	136	35	500	36
The Fossil Cirripedes, by Mr. C. Darwin, *complete*	1851, 1854, 1858*a*	1851, 1854 *	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Mr. H. Woodward, in course of completion	1865, 1868	1866, 1869	1866, 1869	70	15	91	2
The Tertiary Entomostraca, by Prof. Rupert Jones, *complete*	1855	1856	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, *complete*	1849	1849	1850	41	7	176	27
The Fossil Estheriæ, by Prof. Rupert Jones, *complete*	1860	1862	1863	139	5	158	19*i*
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter (incomplete through the Author's death)	1862, 1863, 1864, 1866	1864, 1865, 1866, 1867	1864, 1865, 1866, 1867	216	31	703	114
The Malacostracous Crustacea (comprising those of the London Clay, Gault, and Greensands), by Prof. T. Bell, in course of completion	1856, 1860	1857, 1862	1858, 1863	88	22	215	50
Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, *complete*	1850, 1852, 1853, 1854	1851, 1852, 1853, 1854	1851, 1852, 1853, 1855	409	42	1855	160
,, ,, Vol. II. The Permian and Carboniferous Brachiopoda, *complete*	1856*d*, 1857, 1858, 1859, 1860	1857, 1858, 1860, 1861 †	1858, 1859, 1861, 1861, 1863	331	59	1909	157
,, ,, Vol. III. The Devonian and Silurian Brachiopoda, in course of completion	1862, 1863, 1865, 1866, 1868	1864, 1865, 1866, 1867, 1869	1864, 1865, 1866, 1867, 1869	379	57	2245	246
The Mollusca of the Crag, by Mr. S. V. Wood:— Vol. I. (Univalves), *complete*	1847, 1855*b*	1848	1848, 1857	216	21	581	244
Vol. II. (Bivalves), *complete*	1850, 1853, 1855, 1858*c*	1850, 1853, 1856, 1860	1851, 1853, 1857, 1861	344	31	691	253
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, in course of completion	1848, 1852, 1854, 1855, 1858	1849, 1852, 1854, 1856, 1860	1849, 1852, 1855, 1857, 1861	332	33	578	161
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood, in course of completion	1859, 1862	1861, 1864	1861, 1864	136	20	396	146
The Great Oolite Mollusca, by Prof. Morris and Dr. Lycett, *complete*	1850, 1853, 1854	1850, 1853, 1854	1850, 1853, 1855	282	30	816	419
,, ,, ,, Supplement by Dr. Lycett, *complete*	1861	1863	1863	129	15	337	194
The Belemnites, by Prof. Phillips, in course of completion	1863, 1864, 1866, 1868, 1869	1865, 1866, 1867, 1869, 1870	1865, 1866, 1867, 1869, 1870	128	36	622	69
The Upper Cretaceous Cephalopoda, by Mr. D. Sharpe, *complete*	1853, 1854, 1855	1853, 1854, 1856	1853, 1855, 1857	67	27	319	79
The Fossils of the Permian Formation, by Prof. King, *complete*	1849, 1854*e*	1850 *	1850, 1855	287	29	511	138
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, in course of completion	1867, 1869	1868, 1870	1868, 1870	62	14	195	21
The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Profs. Owen and Bell, *complete*‡	1848, 1849, 1856*f*	1849, 1850 *	1849, 1850, 1859	150	58	304	39
The Reptilia of the Cretaceous Formations, by Prof. Owen, *complete*‡	1851, 1857, 1858, 1862	1851, 1859, 1860, 1864	1851, 1859, 1861, 1864	184	59	519	26
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, *complete*‡	1853, 1854, 1855, 1856, 1857, 1858, 1862	1853, 1854, 1856, 1857, 1859, 1860, 1864	1853, 1855, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Kimmeridge Clay Formation, by Prof. Owen, in course of completion	1859, 1860, 1868	1861, 1862, 1869	1861, 1863, 1869	16	6	23	3
The Reptilia of the Liassic Formations, by Prof. Owen, in course of completion	1859,‖ 1860,‖ 1863, 1869	1861, 1862, 1865, 1870	1861, 1863, 1865, 1870	121	37	177	8
The Crag Cetacea, by Prof. Owen, in course of completion	1869	1870	1870	40	5	43	7
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford, in course of completion	1864, 1867, 1868	1866, 1868, 1869	1866, 1868, 1869	218	25	213	2
			TOTAL	6,405	1,006	18,491	3,541

a Index. *b* Title-page to Univalves. *c* Note to Crag Mollusca. *d* Contains the Permian, which is complete. *e* Two corrections of Plates. *f* Supplement.
g Many of the species are described, but not figured. *h* British species only reckoned. *i* British species only reckoned. *k* A Supplement is now in course of publication.
l Wants Index. *m* Useful in binding up the parts. *n* Useful for establishing the dates of new species. * Dates not given. † Marked 1857—1862.
‡ Title-pages and Index will be found in the 1864 Volume, or may be had separately. ‖ Marked on outside label 'Reptilia of Oolitic Formations.'

STRATIGRAPHICAL TABLE *exhibiting the* BRITISH FOSSILS *already figured and described in the* ANNUAL VOLUMES (1847—1869) *of the* PALÆONTOGRAPHICAL SOCIETY.

	PLANTS.	PROTOZOA.		RADIATA.		ARTICULATA.						MOLLUSCA.				VERTEBRATA.		
		Sponges.	Foraminifera.	Corals.	Echinodermata.	Cirripedes.	Cypridæ, Cytherinæ, &c.	Estheriæ.	Merostomata.	Trilobites.	Malacostracous Crustacea.	Polyzoa.	Brachiopoda.	Monomyaria, Dimyaria, and Gasteropoda.	Cephalopoda.	Fishes.	Reptiles.	Mammalia.
Pleistocene ...	...	...	...	...	.....	.....	...	...	.....	.....	...	...	.....	.....	...	...	.....	1864, 1867, 1868
Crag	...	...	1865	1849	1852	1851, 1854	...	...	.....	.....	...	1857	1852	1847, 1850, 1853, 1855	...	...	.....	1869
Eocene	...	...	...	1849, 1865	1852	1851, 1854	1855	...	.....	.....	1856	...	1852	1852, 1854, 1855, 1858, 1859, 1862	1848	...	1848, 1849, 1856	
Cretaceous ...	...	...	...	1849, 1868, 1869	1862, 1867, 1869	1851, 1854	1849	...	.....	.....	1860	...	1852, 1854	.....	1853, 1854, 1855	...	1851, 1857, 1858, 1862	
Wealden	...	...	...	...	.....	.....	...	1860	.....	.....	...	...	.....	.....	...	...	1853, 1854, 1855, 1856, 1857, 1862	
Oolitic	...	...	...	1851	1855, 1856, 1857, 1858, 1861	1851	...	1860	.....	.....	...	...	1850, 1852	1850, 1853, 1854	1850, 1861, 1868, 1869	...	(Purbeck) 1853, 1858 (Kim. Clay), 1859, 1860, 1868	
Liassic	...	...	...	1851, 1866, 1867	1855, 1856, 1858, 1861, 1864	.....	...	...	.....	.....	...	...	1850, 1852	.....	1863, 1864, 1866, 1868	...	1859, 1860, 1863, 1869	
Triassic	...	...	...	...	.....	.....	...	1860										
Permian	1849	1849	1849	1849, 1852	1849	.....	1849	1860	.....	.....	...	1849	1849, 1856	1849	1849	1849	1849	
Carboniferous	1867	...	...	1852	.....	.....	...	1860	.....	.....	...	...	1856, 1857, 1858, 1859, 1860					
Devonian	...	...	...	1853	.....	.....	...	1860	1865, 1868	1862	...	...	1862, 1863	.....	...	1867, 1869		
Silurian	...	...	...	1854	.....	.....	...	...	.....	1862, 1863, 1864, 1866	...	...	1865, 1866, 1868					
Cambrian	...	...	...	...	.....	.....	...	...	.....	1864								

NOTE.—The numbers in the above List refer to the Volumes issued for those Dates.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1869.

LONDON:
MDCCCLX.

A MONOGRAPH

OF THE

BRITISH FOSSIL CORALS.

SECOND SERIES.

BY

P. MARTIN DUNCAN, M.B. LOND., F.R.S.,

FELLOW OF, AND SECRETARY TO, THE GEOLOGICAL SOCIETY.

Being a Supplement to the
'Monograph of the British Fossil Corals,' by MM. MILNE-EDWARDS *and* JULES HAIME.

PART II, No. 2.

CORALS FROM THE UPPER GREENSAND OF HALDON, FROM THE GAULT, AND THE LOWER GREENSAND.

Pages 27—46; Plates X—XV.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1870.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

CONTENTS.

PAGE

I. Corals from the Upper Greensand of Haldon 27

II. Corals from the Gault; Description of New, and Notes on Old Species. 31

III. List of Species from the Gault 38

IV. Corals from the Lower Greensand; Description of New, and Notices of Old Species 39

V. List of New Species 43

VI. List of Species from the Lower Greensand 43

VII. List of Species from the Cretaceous Formations 44

A MONOGRAPH

OF THE

BRITISH FOSSIL CORALS.

(SECOND SERIES.)

PART II.—No. 2.

I.—CORALS FROM THE UPPER GREENSAND OF HALDON.

SOME time after the 'Supplement to the Monograph of the Fossil Corals of the Upper Greensand' was published several very interesting specimens of fossil Corals were submitted to examination from the deposit at Haldon, in Devonshire.[1] It was necessary to describe them, for they had not been previously noticed, and this could not be done before the Corals from the Red Chalk were published. The Corals from Haldon should have been described amongst those of the Upper Greensand. It is, of course, evident that the list of Upper Greensand species (p. 23) is incomplete.

MADREPORARIA APOROSA.

FAMILY—ASTRÆIDÆ.

Sub-family—EUSMILINÆ.

Genus—PLACOSMILIA.

1. PLACOSMILIA CUNEIFORMIS, *Ed. and H.* Pl. X, figs. 1—5.

The corallum is much compressed, and deltoid in shape.

The costæ are delicate, close, slightly prominent, and subequal.

[1] Mr. Vicary, of Exeter, had collected the fossils himself, and pointed out to me their siliceous condition of fossilization.

The calicinal fossa is very narrow, long, and shallow.

The septa are close, alternately thick and thin. They number (in full-sized calices) 176.

The columella is lamelliform and indistinct.

Locality. Haldon. In the Collection of William Vicary, Esq., F.G.S., Exeter.

The specimen figured in Pl. X is a young corallum, and has only five cycles of septa. Its granular costæ and the peculiar striation of its septa are very characteristic.

The height of the specimen is $\frac{1}{2}$ inch, and the length of the calice is rather more. The breadth is $\frac{3}{10}$ths inch.

The *Placosmiliæ* hitherto described are from the Craie tuffeau and the Hippurite Chalk of Soulage and Bains de Rennes (Corbières), Les Martigues, Uchaux, Obourg near Mons, and Gosau.

2. Placosmilia Parkinsoni, *Ed. and H.* Pl. X, figs. 6 and 7.

Placosmilia consobrina, *Reuss.*

The corallum is tall, compressed, conical, and slightly curved.

The costæ are fine and separated by decided intercostal spaces.

The calice is subelliptical in shape.

The fossa is narrow and shallow.

The columella is feebly developed.

There are five cycles of septa, and the laminæ are very unequal.

Locality. Haldon. In the Collection of William Vicary, Esq., F.G.S., Exeter.

The specimen from Haldon is somewhat rolled and worn. The height is $\frac{3}{10}$ths inch. The breadth of the calice is $\frac{3}{10}$ths inch, and its length is $\frac{6}{10}$ths inch.

Placosmilia Parkinsoni has been found at Gosau, in the Corbières, and at Uchaux.

3. Placosmilia magnifica, *Duncan.* Pl. X, figs. 11—13.

The corallum is compressed, short, very elongate, and the calicular margin is curved and rounded.

The calice is very long, curved, rounded at each end, compressed, very open, and shallow.

The septa are unequal, distant, large, and curved; they correspond to costæ of the same size. There are five cycles of septa.

The columella is lamellar, very much developed, thick, continuous, long, and slightly prominent in the calicular fossa.

The costæ are unequal and distant.

The exotheca is inclined and very strongly developed.

Height of the corallum, $1\frac{1}{4}$ to $1\frac{1}{2}$ inch. Length of the calice, $2\frac{1}{2}$ to $3\frac{1}{10}$th inches. Breadth of the calice, $\frac{9}{10}$ths to $1\frac{1}{10}$th inch.

Locality. Haldon. In the Collection of William Vicary, Esq., F.G.S., Exeter.

This fine species is strongly Placosmilian, and might be taken as the type of the genus.

Genus—Peplosmilia.

Peplosmilia depressa, *E. de Fromentel.* Pl. X, figs. 8—10.

The corallum is not very tall, and shows traces of epitheca.

The calice is shallow and round.

The septa are well developed and thin. There are more than four cycles, and probably a fifth exists in full-grown individuals.

The columella is very thin and narrow.

Height, $\frac{1}{2}$ inch. Breadth of calice, $\frac{6}{10}$ths inch.

Locality. Haldon. In the Collection of William Vicary, Esq., F.G.S., Exeter.

M. de Fromentel, 'Pal. Franç., Terr. Crét.,' pl. 46, fig. 1, 1863, and page 241, states that his specimens came from the Upper Greensand of Mans.

The specimen from Haldon is fragmentary, and its columella is defective, but it is so like M. de Fromentel's delineation of *Peplosmilia depressa* that there is no doubt about its being of that species.

Division—Astræaceæ.

Genus—Astrocœnia.

Astrocœnia decaphylla, *Ed. and H.* Pl. XI, figs. 1—6.

This species, described by MM. Milne-Edwards and Jules Haime ('Ann. des Sci. nat.,' 3me série, t. x, p. 298, 1849) was subsequently named *Astræa reticulata* by D'Orbigny (1850), and was noticed as *Astrocœnia magnifica* by Reuss in his great work on the Corals of Gosau ('Denkschr. der Wien Akad. der Wissensch.,' t. vii. p. 94, pl. 8 figs. 4—6, 1854).

Reuss's admirable delineation of the species enables the British form to be recognised

at once, and it even possesses the curious transverse arrangement of the walls of some calices which renders the comprehension of Reuss's sixth figure rather difficult.

The *Astrocœniæ* have been fully considered in the 'Monograph of the Liassic Corals' (Pal. Soc., 1867).

Astrocœnia decaphylla is a rather variable species, on account of the preponderance or deficiency, as the case may be, of cœnenchyma. The size of the costæ is limited by the cœnenchyma, and when this is very deficient they are almost rudimentary.

There are ten principal and ten secondary septa; the secondary are the smallest, and do not reach the styliform columella like the primary. They are slightly spined towards their inner margin. The costæ are small. The columella is well developed, and is essential and styliform. The shape of the calices varies; in some places they are circular, and in others polygonal.

Locality. Haldon. In the Collection of William Vicary, Esq., F.G.S., Exeter.

The British specimens are not to be distinguished from those of the Hippurite Chalk of Gosau, or of the Craie tuffeau of Corbières.

Astrocœnia decaphylla was a very persistent form. It resembles in some of its peculiar structures the Astrocœnias of the Lias, and a specimen from the Miocene coralliferous strata of Jamaica[1] cannot be distinguished from the form from Gosau.

Genus—Isastræa.

Isastræa Haldonensis, *Duncan*. Pl. XI, figs. 7 and 8.

The corallum is hemispherical.

The calices are large, irregular in size, very deep, and rather quadrangular.

The wall is thin.

The septa are crowded, small, long, and there are five cycles of them in the largest calices.

There is a disposition to serial growth in some calices.

Diameter of the largest calices, nearly $\frac{1}{2}$ inch.

Locality. Haldon. In the Collection of William Vicary, Esq., F.G.S., Exeter.

The depth and size of the calices, their thin walls, and the numerous septa, distinguish this species, whose closest allies are *Isastræa lamellosissima*, Michelin, sp., from the Craie tuffeau of Uchaux, *Isastræa Haidingeri*, Ed. and H., from the same formation at Piesting, in the Eastern Alps, and *Isastræa tenuistriata*, M'Coy, sp., of the Inferior Oolite.

[1] Duncan, "West Indian Corals," 'Quart. Journ. Geol. Soc.,' Nov., 1863, vol. xix, page 440.

List of Upper Greensand Corals from Haldon.

1. *Placosmilia cuneiformis*, Ed. and H.
2. „ *Parkinsoni*, „
3. „ *magnifica*, Duncan.
4. *Peplosmilia depressa*, E. de Fromentel.
5. *Astrocœnia decaphylla*, Ed. and H.
6. *Isastræa Haldonensis*, Duncan.

Peplosmilia Austeni, Ed. and H., and *Faria stricta*, Ed. and H., are also found at Haldon. They have been already noticed as Upper Greensand forms.

II.—Corals from the Gault.

Only six well-marked species of Corals were known to MM. Milne-Edwards and Jules Haime as having been found in the Gault. They were all simple or solitary forms, and such as one would expect to find in moderately deep water. It is evident that the area occupied by the English Gault was not the Coral tract of the period. The resemblance of the Coral-faunas of the Gault and the London Clay is somewhat remarkable, and probably the physical conditions of the area during the deposition of the strata were not very dissimilar.

The following pages contain the descriptions of some species which were not known to MM. Milne-Edwards and Jules Haime, and some notices of the most important forms they described.

MADREPORARIA APOROSA.

Family—TURBINOLIDÆ.

Sub-family—Caryophyllinæ.

Division—Caryophylliaceæ.

Genus—Caryophyllia.

MM. Milne-Edwards and Jules Haime have changed the generic term *Cyathina* into that of its predecessor *Caryophyllia*; consequently *Cyathina Bowerbanki*, Ed. and H., is now called *Caryophyllia Bowerbanki*, Ed. and H. ('Hist. Nat. des Corall.,' vol. ii, p. 18

A very interesting variety of this species is in the Rev. T. Wiltshire's Collection, and has its costæ running obliquely to the long axis of the corallum. They are profusely granulated (Pl. XII, figs. 8, 9).

Division—Trochocyathaceæ.

Genus—Trochocyathus.

1. Trochocyathus Harveyanus, *Ed. and H.*

This species was described by MM. Milne-Edwards and Jules Haime in their 'Monograph of the British Fossil Corals,' Part I, p. 65. They associated it with two species, which are, as they suggest, indistinguishable, viz. *Trochocyathus Koenigi* and *Trochocyathus Warburtoni*. The first of these species is the *Turbinolia Koenigi* of Mantell.

An examination of a series of specimens attributed to *Trochocyathus Harveyanus*, Ed. and H., and the consideration of the value of the *Trochocyathi* just mentioned, have led me to recognise five forms of *Trochocyathi breves*, all closely allied and well represented by the original type of *Trochocyathus Harveyanus*, Ed. and H. When placed in a series with this *Trochocyathus* at the head, there is a gradation of structure which prevents a strictly specific distinction being made between the consecutive forms; but when the first and the last forms are compared alone, no one would hesitate to assert that there is a specific distinction between them. All the forms are simple, short, and almost hemispherical; all have four cycles of septa, and the same proportion of pali. These are the primary and most essential peculiarities of the genus.

The costæ differ in their size, prominence, ornamentation, and relation to the septa in some of the forms; and the exsert nature of the septa, their granulation, and the size of the corallum, also differ. The structural differences are seen in many examples, and are therefore more or less persistent; nevertheless it is found that, whilst several specimens have the septa springing from intercostal spaces instead of from the ends of the costæ, one or more, having all the other common structural peculiarities, present septa arising from the costal ends. This method of origin can hardly constitute a specific distinction. I propose to retain *Trochocyathus Harveyanus* as the type of a series of forms the sum of whose variations in structure constitutes the species.

Variety 1 (Pl. XIII, figs. 1, 2).—The corallum is nearly double the size of the type; its septa are rather exsert, and are very granular.

The costæ are very prominent, ridged, marked with numerous small pits, and are continuous with the septa.

The epitheca is waved and well developed. The spaces between the larger costæ are more or less angular.

The peduncle is large.

Locality. Gault, Folkestone. In the British Museum.

Variety 2 (Pl. XIII, figs. 3, 4).—The corallum is as large as that of variety 1, but it is more conical.

The costæ are less pronounced, and the septa, which are more granular than those of variety 1, arise from the intercostal spaces. The costal ends are very elegant in shape, and form a margin of rather sharp curves, side by side.

Locality. Gault, Folkestone. In the British Museum.

Variety 3 (Pl. XII, figs. 1, 3, 4; and Pl. XIII, fig. 13).—The corallum is rather flat, but hemispherical.

The septa are not exsert, and they arise from the costal ends.

The costæ are equal; none are more prominent than others. They are all rather broad, flat, and beautifully ornamented with diverging curved lines. Their free ends are equal and curved.

Locality. Gault, Folkestone. In the Collection of the Rev. T. Wiltshire, F.G.S.

Variety 4.—The corallum and costæ are like Variety 3, but the septa arise from the intercostal spaces.

Locality. Gault, Folkestone. In the Collection of the Rev. T. Wiltshire, F.G.S.

Variety 5 (Pl. XII, fig. 2).—The corallum is rather more conical inferiorly than in Varieties 3 and 4.

The septa are exsert, and project slightly beyond the costal margin.

The costæ are all rudimentary.

The epitheca is well developed, and reaches up to the septa.

Locality. Gault, Folkestone.

The forms may be distinguished as follows:

With more or less ridged costæ	The type. Variety 1. „ 2.
With nearly equal flat costæ	Variety 3. „ 4.
Costæ rudimentary	Variety 5.
Septa arising from the costal ends	The type. Variety 1. „ 3.
Septa arising from the intercostal spaces	Variety 2. „ 4.

All the forms have four cycles of septa and pali before the first, second, and third orders.

An ill-developed and monstrous form is shown in Pl. XIV, figs. 1—5.

2. Trochocyathus Wiltshirei, *Duncan*. Pl. XIV, figs. 10—12.

The corallum is straight, conical, and either cylindrical above or compressed. Its base presents the trace of a peduncle for attachment.

The epitheca is scanty and in transverse masses.

The costæ are distinct and subequal.

The calice is very open and rather deep.

The septa are unequal, hardly exsert, and broad at the margin of the calice. There are four cycles of septa, and six systems.

The pali are large, and are placed before all the cycles except the last.

The columella is rudimentary.

Height, $\frac{3}{10}$ths inch. Breadth of calice, $\frac{3}{10}$ths inch.

Locality. Gault, Folkestone. In the Museum of the Royal School of Mines, and in the Collection of the Rev. T. Wiltshire, F.G.S.

This species is closely allied to *Trochocyathus conulus*, Phillips, sp. The compressed calice, the rudimentary columella, and the shape of the corallum, distinguish the new species from *Trochocyathus conulus*.

Genus—Leptocyathus.

1. Leptocyathus gracilis, *Duncan*. Pl. XIII, figs. 5—8.

The corallum is small, flat, and circular in outline.

The costæ are very prominent, and join exsert septa. The primary and secondary costæ are very distinct, and the others less so. All the costæ unite centrally at the base. Many are slightly curved.

The septa are thick externally, very unequal, thin internally, and the largest are more exsert than the others. There are six systems and four cycles of septa.

The pali are small and exist before all the septa.

The columella is very rudimentary.

The calicular fossa is rather wide and shallow.

Height, hardly $\frac{1}{10}$th inch. Breadth, $\frac{3}{10}$ths inch.

Locality. Gault, Folkestone. In the British Museum.

This species is very closely allied to *Leptocyathus elegans*, Ed. and H., of the London

Clay. *Leptocyathus elegans* has not a flat base, and it has very granular septa. Moreover, its costæ are large and small in sets. Nevertheless the alliance is of the closest kind.

Genus—Bathycyathus.

MM. Milne-Edwards and Jules Haime described a species of this genus in their 'Monograph of the British Fossil Corals,' Part I, pp. 67, 68. Two specimens in the Collection of Rev. T. Wiltshire present all the appearances recognised by those distinguished authors. The costæ are very granular, and not in a simple row. In one specimen the breadth of the base is very great (Pl. XII, figs. 5—7).

Family—TURBINOLIDÆ.

Sub-Family—Turbinolinæ.

Division—Turbinoliaceæ.

Genus—Smilotrochus.

Some species of this genus were described amongst the Corals from the Upper Greensand,[1] and one was noticed as belonging to this geological horizon which should have been included with the Lower Greensand forms.

The Upper Greensand *Smilotrochi* are—

Smilotrochus tuberosus, Ed. and H.
„ *elongatus*, Duncan.
„ *angulatus*, „

There are four species of the genus found in the Gault, which are all closely allied. One of them cannot be distinguished from *Smilotrochus elongatus* of the Upper Greensand.

The specimens of this species found in the Upper Greensand are invariably worn and rolled, and are generally in the form of casts; but in the Gault the structural details are well preserved, and even the lateral spines on the septa are distinct.

The Gault forms are shorter and more cylindro-conical and curved than those from the Upper Greensand.

[1] See *antè*, p. 19.

The species of the genus *Smilotrochus* from the Gault are as follows:

1. *Smilotrochus elongatus*, Duncan.
,, *cylindricus*, ,,
,, *granulatus*, ,,
,, *insignis*, ,,

1. Smilotrochus elongatus, *Duncan*. Pl. XII, figs. 10—16; Pl. XIII, figs. 10—12; and Pl. XIV, figs. 13—15.

This species is described at page 19 of the first number of this Part, and is figured in Pl. VII, figs. 1—6.

Locality. Folkestone. In the Collection of the Royal School of Mines.

The lateral spines of the septa are very well marked, and the costæ are equal in size in this species. Its septal number varies, on account of the very late perfection of the fourth cycle of septa.

2. Smilotrochus cylindricus, *Duncan*. Pl. XIV, fig. 16.

The corallum is small, cylindrical, nearly straight, and has a truncated base.

The costæ are equal, very distinct above, and rudimentary below and in the middle. They are marked with a few large granules in one series.

The septa are subequal, very exsert, thin, close, and marked with large granules, few in number. The septa are in six systems, and there are three cycles.

Height, $\frac{3}{10}$ths inch. Greatest breadth, rather less than $\frac{2}{10}$ths inch.

Locality. Gault, Folkestone. In the Collection of the Rev. T. Wiltshire, F.G.S.

3. Smilotrochus granulatus, *Duncan*. Pl. XIV, fig. 17.

The corallum is conico-cylindrical in shape, and has a more or less truncated base.

The costæ are subequal, prominent, very granular, and distinct superiorly.

The septa are subequal, thick, and very granular. The septa are in six systems, and there are three cycles.

Height, $\frac{2}{10}$ths inch. Breadth, $\frac{3}{20}$ths inch.

Locality. Gault, Folkestone. In the Collection of the Rev. T. Wiltshire, F.G.S.

4. Smilotrochus insignis, *Duncan*. Pl. XII, fig. 17; and Pl. XIV, fig. 18.

The corallum is trochoid, short, and has a wide calice, and a conical and rounded base.

The calice is circular in outline; the fossa is deep and small, and the septa are wide, exsert, curved above, and so marked with one row of granules that their free margin appears to be spined. There are three cycles of septa, and the orders are nearly equal as regards size.

The costæ are large, prominent, broad at their base, and are marked with one row of granules on the free surface.

Height, $\frac{2}{10}$ths inch. Breadth of calice, $\frac{2}{10}$ths inch.

Locality. Gault, Folkestone. In the Collection of the Rev. T. Wiltshire, F.G.S.

An analysis of the genus will be found after the description of the species from the Lower Greensand.

There is a compound or aggregate Madreporarian found in the Gault of Folkestone. It has much endotheca, and resembles worn specimens of the well-known *Holocystis elegans* of the Lower Greensand. The specimens are not sufficiently well preserved for indentification with any genus.

Family—FUNGIDÆ.

Sub-family—Fungin.e.

Genus—Micrabacia.

1. Micrabacia Fittoni, *Duncan*. Pl. XIV, figs. 6—9.

The corallum is nearly hemispherical in shape. Its base is flat, and extends beyond the origin of the septa in a sharp and uninverted margin. The breadth of the base exceeds the height of the corallum.

The costæ are flat, straight, convex externally at the calicular margin, and equal.

The septa are unequal, much smaller than the costæ. There are four cycles of septa, in six systems.

The synapticulæ between the septa are large.

Height, $\frac{2}{10}$ths. Breadth, nearly $\frac{1}{2}$ inch.

Locality. Gault, Folkestone. In the Collection of the Rev. T. Wiltshire, F.G.S.

The flat base, the flat costæ, and the limitation of the septal number to four cycles, distinguish this species from *Micrabacia coronula*[1] of the Upper Greensand, and from *Micrabacia Beaumontii*[2], Ed. and H., of the Neocomian.

List of New Species from the Gault.

Variety of *Caryophyllia Bowerbanki*, Ed. and H.
Five varieties of *Trochocyathus Harveyanus*, Ed. and H.
Trochocyathus Wiltshirei, Duncan.
Leptocyathus gracilis, ,,
Smilotrochus elongatus, ,,
,, *granulatus*, ,,
,, *insignis*, ,,
,, *cylindricus*, ,,
Micrabacia Fittoni, ,,

III.—List of Species from the Gault.

1. *Caryophyllia Bowerbanki*, Ed. and H., and one variety.
2. *Trochocyathus conulus*, Phillips, sp.
3. ,, *Wiltshirei*, Duncan.
4. ,, *Harveyanus*, Ed. and H., and five varieties.
5. *Bathycyathus Sowerbyi*, Ed. and H.
6. *Leptocyathus gracilis*, Duncan.
7. *Cyclocyathus Fittoni*, Ed. and H.
8. *Smilotrochus elongatus*, Duncan.[3]
9. ,, *granulatus*, ,,
10. ,, *cylindricus*, ,,
11. ,, *insignis*, ,,
12. *Trochosmilia sulcata*, Ed. and H.
13. *Micrabacia Fittoni*, Duncan.

[1] 'Hist. Nat. des Coral.,' vol. iii, p. 30.
[2] Ibid., p. 30.
[3] Common to the Gault and Upper Greensand.

IV.—Corals from the Lower Greensand.

One species of Coral was described by MM. Milne-Edwards and Jules Haime from the Lower Greensand, in their 'Monograph of the British Fossil Corals.'

Fitton had noticed a compound Coral in the Lower Greensand, and named it *Astræa* in his "Essay on the Strata below the Chalk," 'Geol. Trans.,' 2nd series, vol. iv, p. 352, 1843. In 1847 he called the species *Astræa elegans*, and Lonsdale separated it from the *Astræidæ* under the name *Cyathophora? elegans* in 1849 ('Quart. Journ. Geol. Soc.,' vol. v, pt. 1, p. 83, pl. iv, figs. 12, 15, 1849).

MM. Milne-Edwards and Jules Haime recognised the quadrate arrangement of the septa of this species, and classified it amongst the *Rugosa*, in the family *Stauridæ*. Their *Holocystis elegans*, Fitton, sp., is a very good species, and specimens are found varying in the size of the corallum and of the calices.

Since the publication of their 'Monograph on the British Fossil Corals,' MM. Milne-Edwards and Jules Haime have named a species from Farringdon *Smilotrochus Austeni* ('Hist. Nat. des Corall.,' vol. ii, p. 71). I have noticed it inadvertently in my description of the Upper Greensand Corals, p. 19, and Pl. VII, fig. 12. In order to complete this part it is introduced here again.

Family—TURBINOLIDÆ.

Division—Turbinoliaceæ.

Genus—Smilotrochus.

1. Smilotrochus Austeni, *Ed. and H.* Pl. VII, fig. 12.

The corallum is regularly cuneiform, very much compressed below, and slightly elongate.

[1] The following authors have written upon the Fossil Corals of the Gault:
MM. Milne-Edwards and Jules Haime, 'Monograph of the British Fossil Corals;' Pal. Soc.
" " 'Hist. Nat des Coralliaires.'
Phillips, 'Illust. of Geol. of Yorkshire.'
Mantell's 'Geol. of Sussex,' Lonsdale in.
Fleming, 'British Animals.'
The authors who have written upon the Corals of the Lower Greensand are—
MM. Milne-Edwards and Jules Haime, opp. citt.
Fitton, 'Quart. Journ. Geol. Soc.,' vol. iii, p. 296, 1847.
Lonsdale, 'Quart. Journ. Geol. Soc.,' vol. v, p. 83.
M. de Fromentel has paid especial attention to the French Neocomian Corals; and C. J. Meyer, Esq., F.G.S., has enabled me to study the most interesting species in his collection.

The calice is elliptical; the summit of the larger axis is rounded.

Forty-eight costæ, subequal, straight, fine, and granular.

Height of the corallum, about $\frac{1}{3}$rd inch.

Locality. Farringdon.

MM. Milne-Edwards and Jules Haime do not mention where their specimen is deposited. Mr. Vicary, of Exeter, has a fine specimen of this Coral.

The genus *Smilotrochus* has become of some importance in the palæontology of the Cretaceous rocks. The species are distributed as follows in Great Britain:

Smilotrochus tuberosus, Ed. and H.
„ *elongatus*, Duncan } Upper Greensand.
„ *angulatus*, „

„ *elongatus*, „
„ *granulatus*, „
„ *insignis*, „ } Gault.
„ *cylindricus*, „

„ *Austeni*, Ed. and H. Lower Greensand.

Smilotrochus elongatus, Duncan, is found in the Gault and Upper Greensand. *Smilotrochus Hagenowi*, Ed. and H., is a fossil from the Maestricht Chalk (Ed. and H., 'Hist. Nat. des Corall.,' vol. ii, p. 71). *Smilotrochus irregularis*, E. de Fromentel, is a small cornute form, with rounded primary costæ and rather an open calice; it is from the Chalk ('Pal. Franç.,' tome viii, livraison 4, Zooph., pl. ix).

Sub-family—Caryophyllinæ.

Division—Caryophylliaceæ.

Genus—Brachycyathus.

1. Brachycyathus Orbignyanus, *Ed. and H.* Pl. XV, figs. 8, 9.

The corallum is very short.

The costæ are indistinct.

The septa are long, very slightly exsert, granulated from below upwards, and there are four cycles in six systems. The primary and secondary septa are equal. The tertiary are a little longer than those of the fourth cycle. All are thin and straight.

The pali are like continuations of the tertiary septa before which they are placed. They are granular.

Height, $\frac{1}{10}$th inch. Breadth, $\frac{6}{10}$ths inch.

Locality. East Shalford, Surrey. Base of the Lower Greensand; found with *Cerithium Neocomiense*, D'Orb.; *Exogyra subplicata*, Tqm.; *Area Raulini*, Leym.; *Terebratula sella*, Sow. In the Collection of C. J. A. Meyer, Esq., F.G.S.

The specimen upon which the genus was founded was found in the Neocomian formation of the Hautes Alpes, at St. Julien, Beauchêne. I have added to the original description, as some portions of the English specimen are better preserved than the type.

FAMILY—ASTRÆIDÆ.

Sub-family—EUSMILINÆ.

Division—TROCHOSMILIACEÆ.

Genus—TROCHOSMILIA.

TROCHOSMILIA MEYERI, *Duncan*. Pl. XV, figs. 1—7.

The corallum is small, cylindrical or cylindro-conical. Its base may be wide or very small, and was adherent.

The epitheca is complete.

The costæ are very small, and are occasionally seen where the epitheca is worn.

The calice is rather deep.

The septa are crowded, unequal, spined near the axis, and form six systems. There are four cycles of septa.

The calice is usually circular in outline, but it is occasionally compressed.

The axial space is small.

The endotheca is very scanty.

Height, $\frac{4}{10}$ths inch. Greatest breadth, $\frac{2}{10}$ths inch.

Variety.—The corallum is short, broad, cylindrical, slightly constricted centrally, and has a broad base.

Height, $\frac{3}{20}$ths inch. Breadth, $\frac{6}{20}$ths inch.

Locality. Bargate Stone; upper division of the Lower Greensand. Guildford, Surrey. Found with *Avicula pectinata*, Sow. In the Collection of C. J. A. Meyer, Esq., F.G.S.

These small *Trochosmiliæ* are common in the Bargate Stone, where they were discovered by Mr. Meyer, from whom I have obtained the names of the associated fossils. The presence of epitheca would apparently necessitate these fossils being placed in a new genus, but, after a careful examination of the bearings of the absence or presence of

epithecal structures upon the natural classification of simple Corals, I do not think the point sufficiently important to bring about the separation of Mr. Meyer's little Corals from the *Trochosmiliæ*. They form (*i. e.* the type and the variety) a sub-genus of the *Trochosmiliæ*.

Sub-family—Astræinæ.

Division—Astræaceæ.

Genus—Isastræa.

Isastræa Morrisii, *Duncan*. Pl. XV, figs. 10—12.

The corallum is flat and very short. The corallites are unequal, and usually five-sided.

There is no columella.

The wall is thin.

The septa are slender, unequal, and most of them reach far inwards. There are in the perfect calices three cycles of septa in six systems. Usually some of the septa of the third cycle are wanting.

Breadth of a calice, rather more than $\frac{1}{10}$th inch.

Locality. Bargate Stone, Guildford, Surrey; with *Terebratella Fittoni*, Meyer. In the Collection of C. J. A. Meyer, Esq., F.G.S.

This small *Isastræa* is usually found as a cast, and the restored drawing is taken from an impression. The central circular structure is due to fossilization.

The species is closely allied to *Isastræa Guettardana*, Ed. and H., of the Lower Chalk of Uchaux.

Family—FUNGIDÆ.

Sub-family—Lophoserinæ.

Genus—Turbinoseris.

Genus nov.—Turbinoseris. The corallum is simple, more or less turbinate, or constricted midway between the base and calice. The base is either broad and adherent, or small and free.

There is no epitheca, and the costæ are distinct.

There is no columella, and the septa unite literally, and are very numerous.

TURBINOSERIS DE-FROMENTELI, *Duncan*. Pl. XV, figs. 13—18.

The corallum is tall, and more or less cylindro-turbinate.

The calice is shallow, and circular in outline.

The septa are very numerous, long, thin, straight, and many unite laterally with longer ones. There are 120 septa, and the cyclical arrangement is confused.

The synapticulæ are well developed.

There is no columella, and the longest septa reach across the axial space.

The costæ are well developed, and often are not continuous with the septal ends.

Height, $1\frac{3}{10}$ths inch. Breadth of calice, $1\frac{2}{10}$ths inch.

Variety.—With a constricted wall and large base.

Locality. Atherfield, in the Lower Greensand. In the Collection of the Royal School of Mines.

The necessity for forming a new genus for this species is obvious. It is the neighbour of *Trochoseris* in the sub-family of the *Lophoserinæ*. This last genus has a columella, and the new one has none.

The species has not been hitherto described, but it has been familiarly known as a *Montlivaltia*; but the synapticulæ between the septa and costæ determine the form to belong to the *Fungidæ*.

V.—LIST OF NEW SPECIES FROM THE LOWER GREENSAND.

1. *Brachycyathus Orbignyanus*, Ed. and H.
2. *Trochosmilia Meyeri*, Duncan.
3. *Isastræa Morrisii*, ,,
4. *Turbinoseris De-Fromenteli*, ,,

VI.—LIST OF THE SPECIES FROM THE LOWER GREENSAND.

1. *Brachycyathus Orbignyanus*, Ed. and H.
2. *Smilotrochus Austeni*, Ed. and H.
3. *Trochosmilia Meyeri*, Duncan.
4. *Isastræa Morrisii*, ,,
5. *Turbinoseris De-Fromonteli*, ,,
6. *Holocystis elegans*, Lonsdale, sp.

VII.—List of the Species from the Cretaceous Formations.

A. *Upper and Lower White Chalk.*

1. *Caryophyllia cylindracea,* Reuss, sp.
2. „ *Lonsdalei,* Duncan.
3. „ *Tennanti,* „
4. *Onchotrochus serpentinus,* „
5. *Trochosmilia laxa,* Ed. and H., sp., and three varieties.
6. „ *cornucopiæ,* Duncan.
7. „ *Wiltshirei,* „
8. „ *Woodwardi,* „
9. „ *granulata,* „
10. „ *cylindrica,* „
11. *Parasmilia centralis,* Mantell, sp., and two varieties.
12. „ *cylindrica,* Ed. and H.
13. „ *Fittoni,* „
14. „ *serpentina,* „
15. „ *monilis,* Duncan.
16. „ *granulata,* „
17. *Diblasus Gravensis,* Lonsdale.
18. *Synhelia Sharpeana,* Ed. and H.
19. *Stephanophyllia Bowerbanki,* Ed. and H.

B. *Upper Greensand.*

20. *Onchotrochus Carteri,* Duncan.
21. *Smilotrochus tuberosus,* Ed. and H.
22. „ *elongatus,* Duncan.
23. „ *angulatus,* „
24. *Peplosmilia Austeni,* Ed. and H.
25. *Cyathophora monticularia,* D'Orbigny.
26. *Favia stricta,* Ed. and H.
27. „ *minutissima,* Duncan.
28. *Thamnastræa superposita,* Michelin.
29. *Micrabacia coronula,* Goldfuss, sp.
30. *Placosmilia cuneiformis,* Ed. and H.
31. „ *Parkinsoni,* „
32. „ *magnifica,* Duncan.
33. *Peplosmilia depressa,* E. de Fromentel.
34. *Astrocœnia decaphylla,* Ed. and H.
35. *Isastræa Haldonensis,* Duncan.

c. *Red Chalk of Hunstanton.*

36. *Cyclolites polymorpha*, Goldfuss, sp.
37. *Podoseris mammiliformis*, Duncan.
38. „ *elongata*, „
39. *Micrabacia coronula*, Goldfuss, sp., and variety.

d. *Gault.*

40. *Carophyllia Bowerbanki*, Ed. and H., and a variety.
41. *Trochocyathus conulus*, Phillips, sp.
42. „ *Wiltshirei*, Duncan.
43. „ *Harveyanus*, Ed. and H., and five varieties.
44. *Bathycyathus Sowerbyi*, Ed. and H.
45. *Leptocyathus gracilis*, Duncan.
46. *Cyclocyathus Fittoni*, Ed. and H.
47. *Smilotrochus elongatus*, Duncan.
48. „ *granulatus*, „
49. „ *insignis*, „
50. „ *cylindricus* „
51. *Trochosmilia sulcata*, Ed. and H.
52. *Micrabacia Fittoni*, Duncan.

e. *Lower Greensand.*

53. *Brachycyathus Orbignyanus*, Ed. and H.
54. *Smilotrochus Austeni*, „
55. *Trochosmilia Meyeri*, Duncan.
56. *Isastræa Morrisii*, „
57. *Turbinoseris De-Fromenteli*, Duncan.
58. *Holocystis elegans*, Lonsdale, sp.

Micrabacia coronula is common to the Upper Greensand and the Red Chalk. *Smilotrochus elongatus* is found in the Gault and in the Upper Greensand.

The number of species of *Madreporaria* in the British Cretaceous formations is therefore fifty-six.

MM. Milne-Edwards and Jules Haime had described twenty-three species before this

series was commenced. Of these I have ventured to suppress *Parasmilia Mantelli*, *Trochocyathus Koenigi*, and *Trochocyathus Warburtoni*.

The Coral-fauna of the British area was by no means well developed or rich in genera during the long period during which the Cretaceous sediments were being deposited. The Coral tracts of the early part of the period were on the areas now occupied by the Alpine Neocomian strata, and those of the middle portion of the period were where the Lower Chalk is developed at Gosau, Uchaux, and Martigues.

There are no traces of any Coral reefs or atolls in the British Cretaceous area, and its Corals were of a kind whose representatives for the most part live at a depth of from 5 to 600 fathoms.

PLATE X.

CORALS FROM THE UPPER GREENSAND OF HALDON.

Fig.

1. The corallum of *Placosmilia cuneiformis*, Ed. and H. (P. 27.)
2. Part of a septum, magnified.
3. The costæ, magnified.
4. Oblique view of the costæ, magnified.
5. The calice, magnified.
6. The corallum of *Placosmilia Parkinsoni*, Ed. and H. (P. 28.)
7. The calice, magnified.
8. The corallum of *Peplosmilia depressa*, E. de From. (P. 29.)
9. The costæ, magnified.
10. The calice, magnified.

11.
12. } The corallum of *Placosmilia magnifica*, Duncan. (P. 28.)
13.

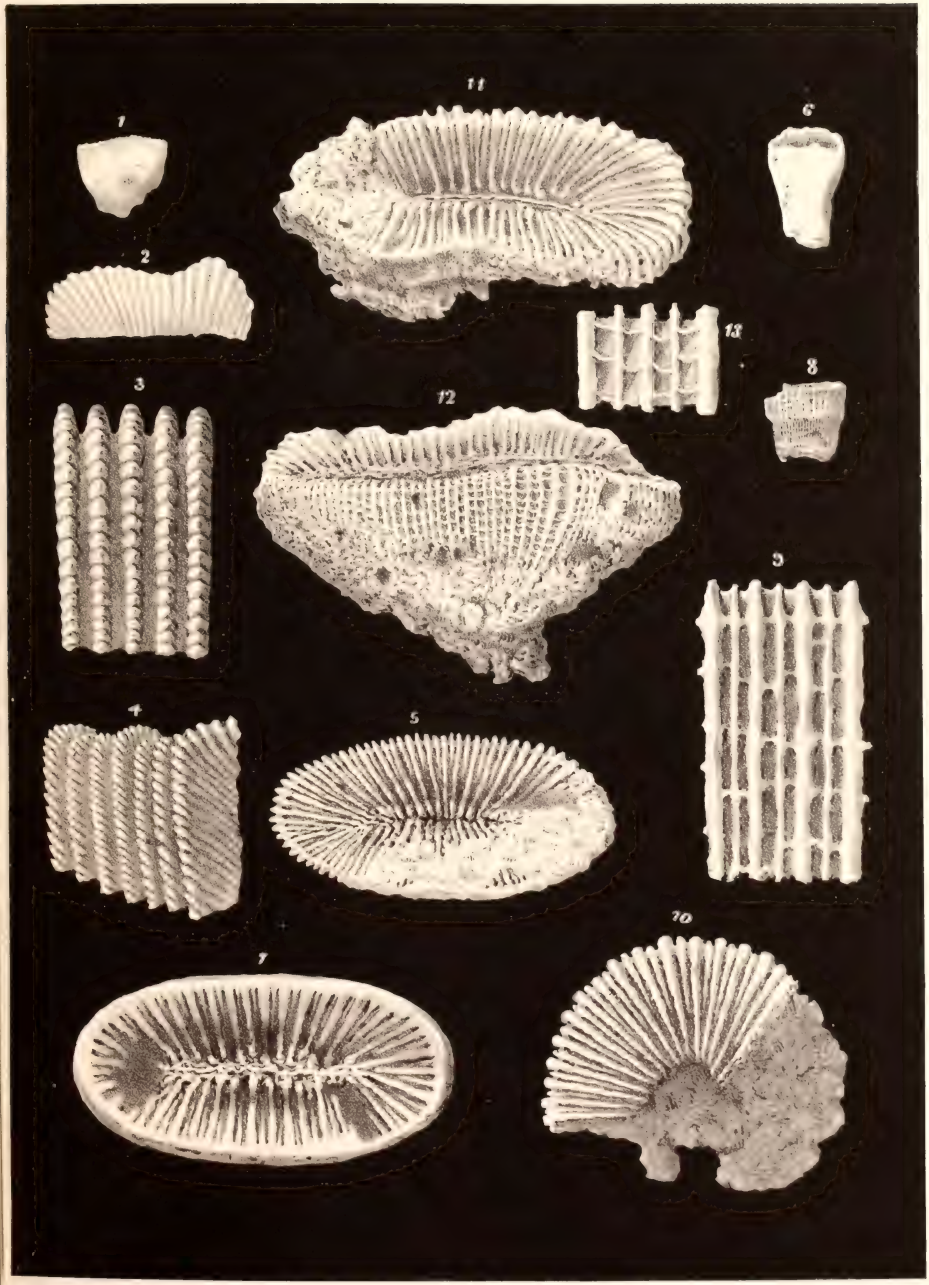

1
11
6
2
13
3
8
12
9
4
5
7
10

PLATE XI.

FIG.

1. The corallum of *Astrocœnia decaphylla*, Ed. and H. (P. 29.)
2. The same, magnified.
3. The upper part of a calice, magnified.
4. The corallum of a variety.
5. The upper part of a calice, magnified.
6. The corallum, magnified.

7. } The corallum and calices of *Isastræa Haldonensis*, Duncan. (P. 30.)
8. }

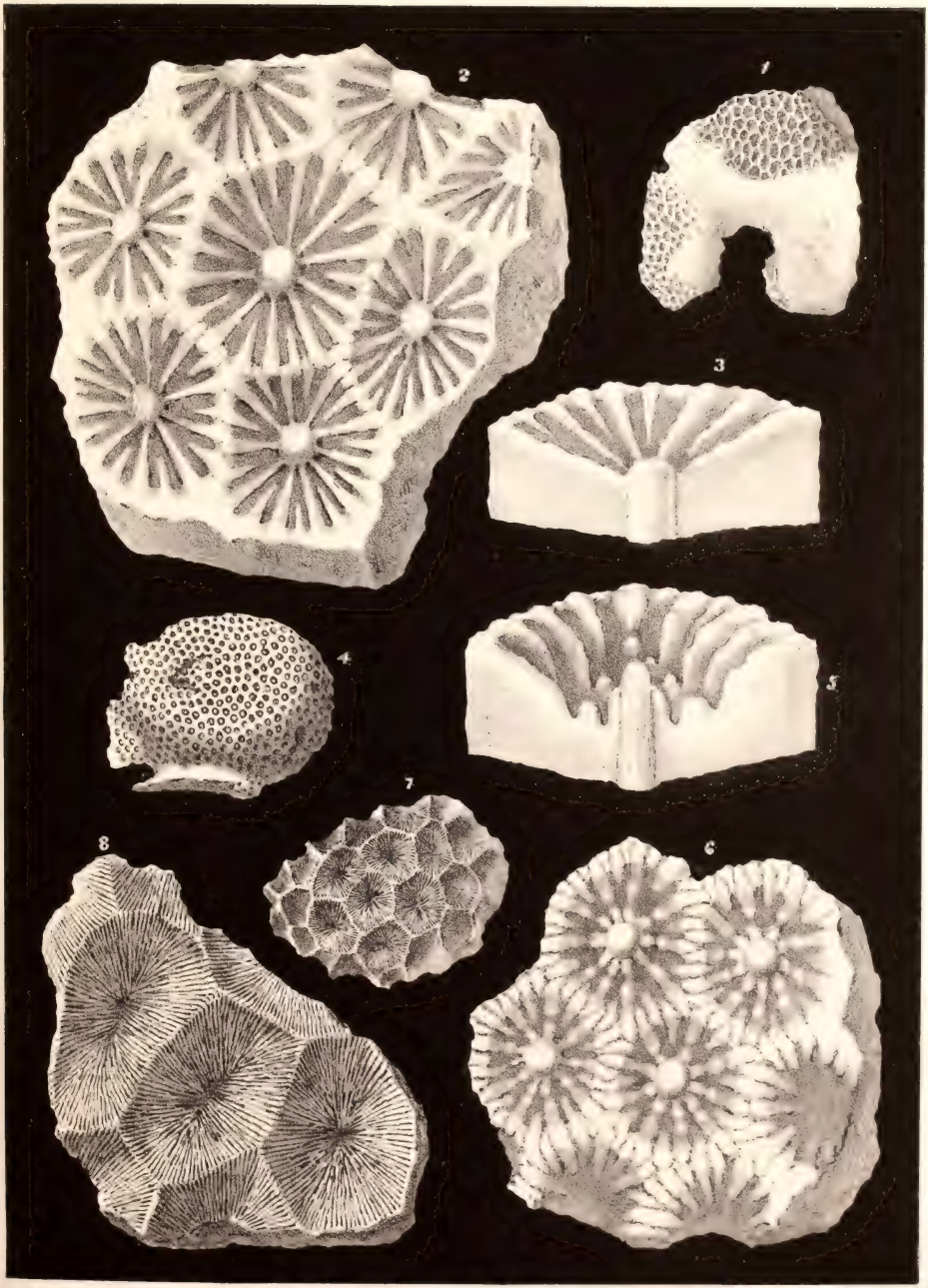

2
1
3
4
5
7
8
6

PLATE XII.

CORALS FROM THE GAULT.

FIG.

1. } Varieties of *Trochocyathus Harveyanus*, Ed. and H. (P. 33.)
2. }

3. Magnified view of the ends of the costæ of one of the varieties.

4. A longitudinal section of a variety, slightly magnified.

5. A variety of *Bathycyathus Sowerbyi*, Ed. and H. (P. 35.)

6. Its costæ, magnified.

7. The corallum of *Bathycyathus Sowerbyi*, Ed. and H. (P. 35.)

8. A variety of *Caryophyllia Bowerbanki*, Ed. and H. (P. 32.)

9. Its costæ, magnified.

10 to 16. Views of *Smilotrochus elongatus*, Duncan. (P. 36.)

12. Costæ, magnified.

14. The calice of a young specimen, magnified.

16. The costæ, magnified.

17. Corallum of *Smilotrochus insignis*, Duncan. (P. 37.)

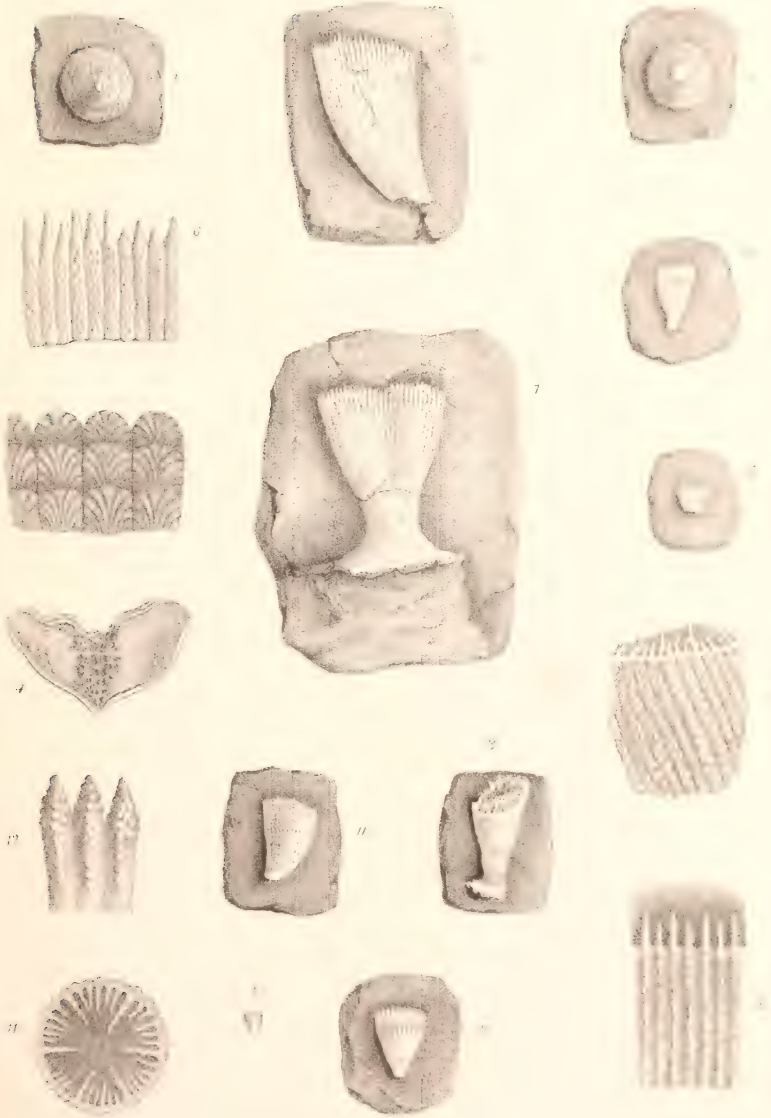


PLATE XIII.

CORALS FROM THE GAULT.

FIG.

1. A variety of *Trochocyathus Harveyanus*, Ed. and H. The base. (P. 32 and 33.)
2. Costæ and septa, magnified.
3. A variety of the same species.
4. Costæ and septa, magnified.
13. A transverse section, magnified.
5. *Leptocyathus gracilis*, Duncan. Under surface. (P. 34.)
6. The under surface or base, magnified.
7. A transverse section, magnified.
8. A side view, magnified.
9. *Smilotrochus insignis*, Duncan. (P. 37.)

10.
11. Young of *Smilotrochus elongatus*, Duncan. (P. 36.)
12.

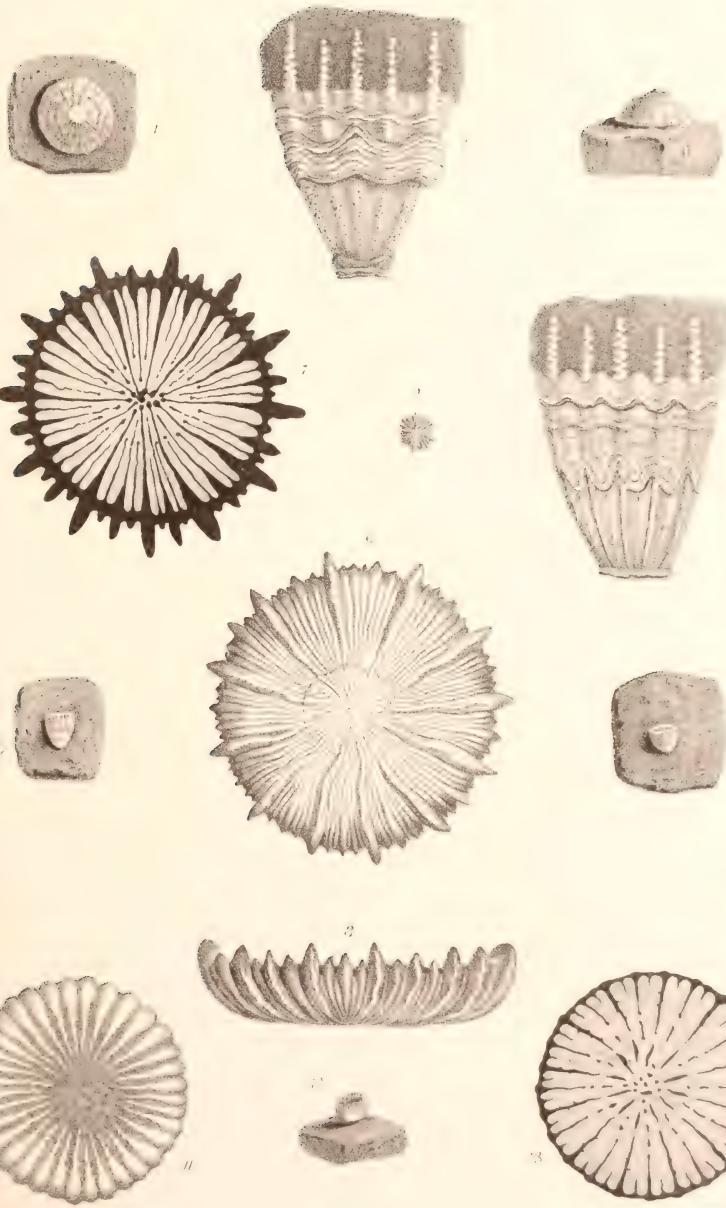


PLATE XIV.

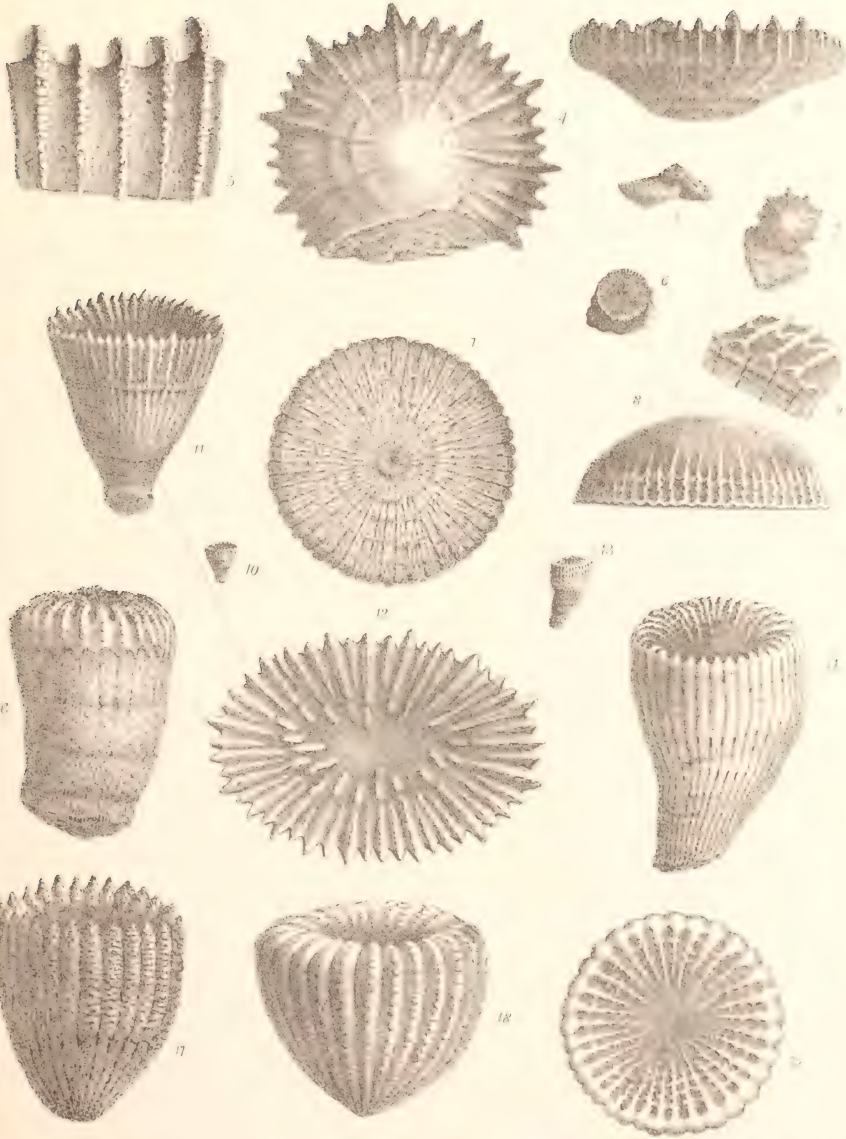
CORALS FROM THE GAULT.

FIG.

1. 2. Abnormal form of *Trochocyathus Harveyanus*, Ed. and H. (P. 34.)

3. 4. 5. Magnified views.

6. Base of *Micrabacia Fittoni*, Duncan. (P. 37.)
7. The same, magnified.
8. Side view of the corallum, magnified.
9. Junction of septa and costæ, magnified.
10. Corallum of *Trochocyathus Wiltshirei*, Duncan. (P. 34.)
11. Magnified view.
12. The calice, magnified.
13. *Smilotrochus elongatus*, Duncan. Adult form. (P. 36.)
14. The same, magnified.
15. The calice, magnified.
16. *Smilotrochus cylindricus*, Duncan. Corallum, magnified. (P. 36.)
17. *Smilotrochus granulatus*, Duncan. Corallum, magnified. (P. 36.)
18. *Smilotrochus insignis*, Duncan. Corallum, magnified. (P. 37.)



De Wilde lith.

CORALS FROM THE GAULT

PLATE XV.

CORALS FROM THE LOWER GREENSAND.

FIG.

1. 2. 3. Corallites of *Trochosmilia Meyeri*, Duncan. (P. 41.)

4. 5. Calices, magnified.

6. Variety with broad base.

7. Its calice, magnified.

8. Part of the corallum of *Brachycyathus Orbignyanus*, Ed. and H. (P. 40.)

9. Longitudinal view of the septa and pali, magnified. The notch indicates the commencement of pali attached to tertiary septa.

10. Corallum (cast) of *Isastræa Morrisii*, Duncan. (P. 42.)

11. The cast, magnified.

12. Impression, magnified.

13. The corallum of *Turbinoseris De-Fromenteli*, Duncan. (P. 43.)

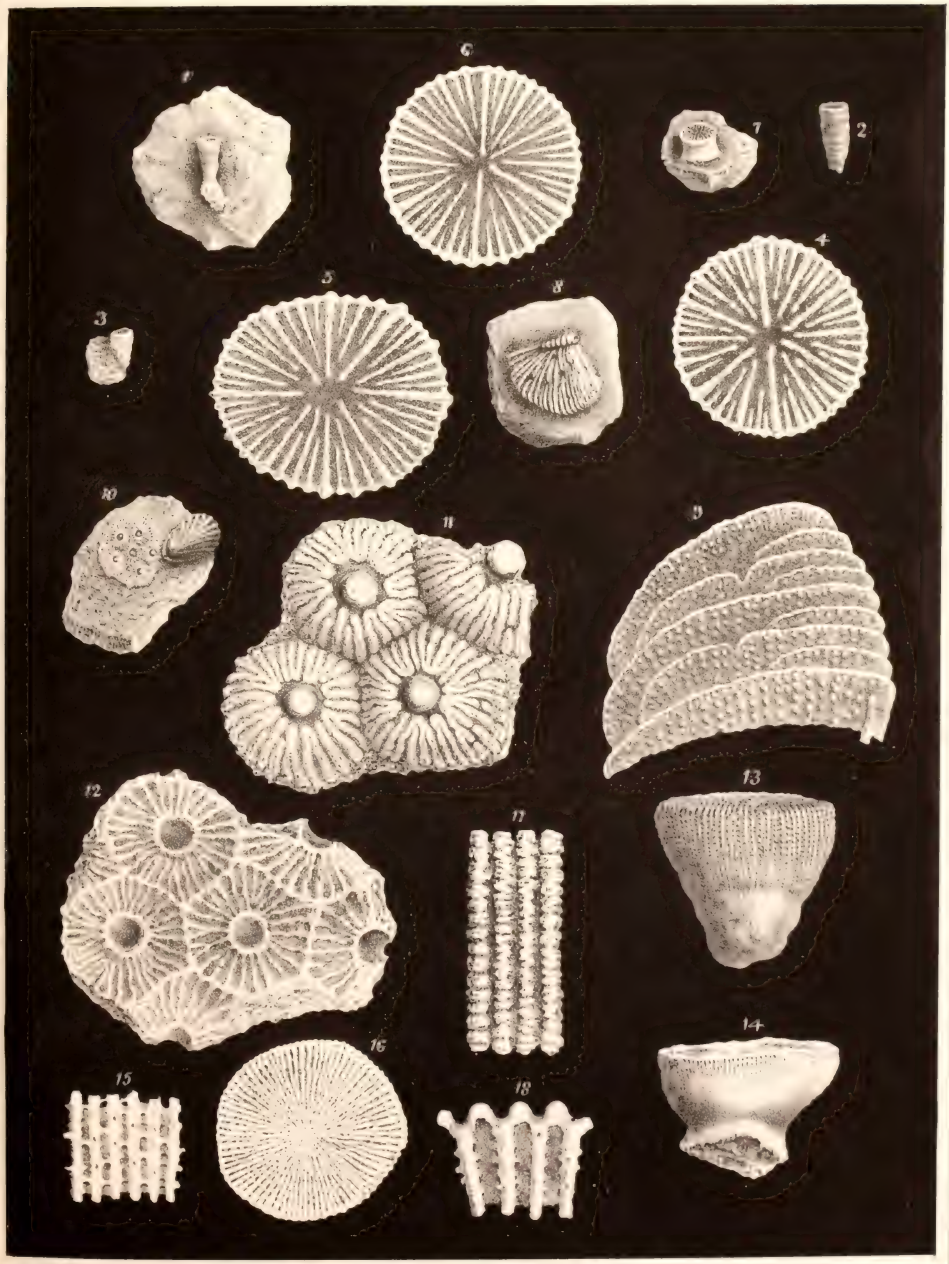
14. A variety.

15. Synapticulæ and septa, magnified.

16. Calice, size of life.

17. Costæ, magnified.

18. The unusual appearance of septa ending in intercostal spaces, magnified.


1
6
7
2
4
3
5
8
10
11
9
12
13
17
14
16
15
18

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1869.

LONDON:
MDCCCLXX.

A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

THOMAS WRIGHT, M.D, F.R.S. Edin., F.G.S.,

CORRESPONDING MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF LIÈGE, THE SOCIETY OF NATURAL SCIENCES OF NEUFCHATEL, AND SENIOR SURGEON TO THE CHELTENHAM HOSPITAL.

VOLUME FIRST.

PART THIRD.

ON THE DIADEMADÆ.

Pages 113—136; Plates XXII—XXIX, XXIXa, XXIXb.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1870.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

The pores are scarcely bigeminal near the summit. The primary tubercles are numerous, nearly uniform in size, and closely set together; the mouth-opening is very small, and lies in a deep depression.

Pseudodiadema variolare has the test in general more depressed, the base wider, and the pores more distinctly bigeminal in the upper fourth of the zones: the base is wider, more convex, and less contracted than in *Ps. Brongniarti*.

Locality and Stratigraphical Position.—*Pseudodiadema Brongniarti* has been collected from the Grey Chalk near Folkestone, from which stratum all the large fine specimens in the British Museum, and those in the Rev. T. Wiltshire's cabinet figured in this Monograph, have been obtained. The Red Chalk of Hunstanton Cliff has yielded a few examples, two of which, from Mr. Rose's and the Rev. T. Wiltshire's collections, are figured in Pl. XXI B. Forms referred to this species have been collected from the Chalk-marl of Maiden Bradley, Dorset, and the Chloritic Marl, Somerset.

Foreign Localities.—Professor Pictet, of Geneva, kindly gave me several type specimens of this Urchin collected from the Gault of the Perte du Rhône (Ain), which so much resemble Professor Agassiz's figures of this species from the same locality that my specimens might have been the originals of the drawings in his 'Échinodermes foss. de la Suisse.' It is found likewise at Escragnolle (Var), Montagne des Fis (Savoie), where it is an abundant fossil in the Étage Albien or the Gault. M. Desor, in addition to these localities, gives Clar and La Presta, as places where this species is abundant.

History.—First figured by M. Al. Brongniart[1] in his 'Description de la Perte du Rhône,' under the name *Cidarites variolaris (?)*, as a characteristic fossil of the Craie Marneuse; afterwards (1840) it was described and figured by Professor Agassiz in the 'Échinodermes foss. de la Suisse' as *Tetragramma Brongniarti*; afterwards (1856) it was removed by M. Desor into his genus *Pseudodiadema*, where it now remains.

Genus—Pedinopsis, *Cotteau*, 1863.

Test large, round, inflated, sometimes subconical. Poriferous zones wide and straight; the pores bigeminal throughout, forming at the upper surface and ambitus two distinct rows, which become more blended together at the infra-marginal region, and are distinct at the base. Tubercles of both areas small, and nearly the same size; summit of the boss finely crenulated, and the mammillon perforated; the tubercles disposed in regular rows, the number varying in the different species, and always diminishing as they approach the summit; coronal plates long, narrow, and granular; mouth-opening large, peristome moderately developed, circumference slightly incised, apical disc small, subcircular, elements feebly united, absent in the specimens known.

[1] 'Description géologique des Environs de Paris,' troisième édition, 1835, p. 174, pl. M, fig. 9.

This genus was established by M. Cotteau in his memoir[1] on 'Les Échinides des Pyrénées,' and placed near *Pseudodiadema*, with which it has many affinities; the tubercles are crenulated and perforated, and the pores bigeminal throughout, a character which is in part possessed by *Ps. Brongniarti*, *variolare*, &c. It has affinities with *Salmacis* in the number of its pores; in this genus, however, they are arranged in triple oblique pairs, whilst in *Pedinopsis* they are regularly bigeminal throughout.

The original specimen was collected from the Neocomian strata of Aude, where it is rare; another of the same species has been found at Caussols (Var); the one which I now figure was obtained from the Chloritic Marl near Chardstock, Somerset.

PEDINOPSIS WIESTI, *Wright*, nov. sp. Pl. XIV, fig. 1; Pl. XXIX A.

Test moderate in size, circular, inflated at the sides, convex on the upper surface, and flat at the base; ambulacra with two complete marginal rows and two inner incomplete rows of tubercles; inter-ambulacra with six rows of turbercles at the ambitus, the two central of which are complete, and the four lateral incomplete; tubercles nearly all of the same size; pores uniformly bigeminal throughout.

Dimensions.—Height one inch; transverse diameter one inch and seven tenths; mouth-opening six tenths of an inch.

Description.—This rare Urchin forms the type of a new genus, established by my friend M. Cotteau for a similar rare species from the Neocomian of Caussols (Var). The test is of moderate size, circular at the ambitus, inflated at the sides, convex on the upper surface, and flattened at the base. The ambulacral areas are moderately wide, and retain their proportional diameter throughout the area; they have two rows of marginal tubercles of small size, which extend from the peristome to the disc (Pl. XXIX A, fig. 1), and are very regular both in size and arrangement; between the base and upper surface two other rows occupy the centre, so that this area at the ambitus is furnished with four rows of tubercles (Pl. XXIX A, fig. 1 *g*), the two inner rows of which disappear at the lower seventh (fig. 1 *h*) and upper third of the areas (fig. 1 *d*); the tubercles are nearly all of the same size; around the base of the bosses some fine granules are sparsely distributed, which form imperfect circlets around them (Pl. XXIX A, figs. 1 *d*, *e*, *f*, *g*, *h*). None of the marginal rows in the specimen is complete, so that the exact number in each series cannot be ascertained; but as thirty can be counted in one incomplete column, six more may be fairly estimated as wanting (fig. 1 *a*, *b*, *c*).

The poriferous zones are moderately wide, and very uniform in diameter throughout,

[1] "Échinides foss. des Pyrénées," p. 16. Extrait du 'Congrès scientifique de France,' 28e session, tenue à Bordeaux, t. iii, pl. ix, 1863.

expanding, however, near the mouth, where an increased number of holes seem almost completely to encircle the peristome (fig. 1 *h*); throughout the zones the pores are very regularly bigeminal, and are grouped into distinct ranges, the small plates forming these zones being beautifully dovetailed into each other (figs. 1 *d*, *g*, *h*); by this arrangement there are from six to seven pairs of holes opposite each ambulacral plate, which gives $36 \times 6 = 216$ pairs of holes in each zone.

The inter-ambulacral areas are rather more than double the width of the ambulacral; the individual plates are long and narrow, being only a little deeper than those of the latter; two rows of tubercles occupy the centre of the plates, and extend very regularly in size and disposition from the peristome to the disc; on the zonal side of this central row a second row extends from the peristome over three fourths of the area, and between the central row and the median suture there is another row of the same length; in addition to these six rows a few additional tubercles are introduced at the zonal and median sides of the widest ambital region of the area. I have shown this character in figs. 1 *g* and *h*, and the gradual disappearance of the tubercles in the upper part of the area is seen in figs. 1 *a* and *c*, and in its lower part in figs. 1 *b* and *h*; between the tubercles a number of small granules are sparsely distributed over the surface of the plates.

The tubercles in this genus are very uniform in size and structure throughout both areas; the boss rises suddenly from the surface of the plate, without any areolar depression; its summit is very finely crenulated only where it closely embraces the mammillon, which is small, prominent, and perforated at the summit; in the widest part of the areas the granules form imperfect circlets around the tubercles, and an increased ornamentation at the ambitus and base; at the upper surface they become more sparse in the ambulacra (fig. 1 *d*), and are almost entirely absent in the inter-ambulacra (figs. 1 *a*, *c*).

The mouth-opening is nearly circular, about one third the diameter of the test (fig. *b*); the peristome is slightly incised and unequally divided, the ambulacral being much longer than the inter-ambulacral lobes, allowing a wider space for the development of pedal pores around the peristome.

The apical disc is absent, and the upper part of the test is unfortunately broken off, so that no indication of the size or form of the disc remains imprinted on the mould.

Affinities and Differences.—The only two species of this genus at present known are *Pedinopsis Meridanensis*, Cotteau, from the Neocomian of Aude; and *P. Wiesti*, Wright, from the Chloritic Marl near Chardstock. These Urchins resemble each other very much; *P. Meridanensis* (Pl. XXIX A, fig. 2[1]) has a greater number of tubercles; and they are likewise larger and more regularly disposed on the plates; the poriferous zones are wider, and the holes larger than in *P. Wiesti*. The bigeminal character of the zones, the smallness of the tubercles, and the thinness of the shell, are special characters by which this Urchin can be readily distinguished from all other congeners.

[1] Copied from M. Cotteau's 'Paléontologie Française,' pl. 1125, for comparison with the English species.

Locality and Stratigraphical Position.—This specimen was collected by Mr. Wiest, from the Chloritic Marl near Chardstock, Somerset, where it is associated with several species of *Echinidæ* that are characteristic of the Upper Greensand formation.

Echinocyphus, *Cotteau*, 1860.

Glyphocyphus (pars), *Desor*, 1856.
Cyphosoma (pars), *Woodward*, 1857.
Echinocyphus, *Cotteau*, 1860.

Test small, circular, moderately high, more or less inflated on the upper surface, very concave at the base. Poriferous zones straight, and composed of simple pores throughout. Ambulacral and inter-ambulacral tubercles nearly the same size in both areas, bosses crenulated, mammillon not perforated. In many specimens the ambulacra have only one row of tubercles instead of two, their normal number.

The inter-ambulacral plates are marked at the base with more or less well-marked sutural and horizontal impressions. Peristome moderately large, subcircular, sunk in a depression, and provided with slight lobes. Apical disc unknown, opening elongated and subpentagonal, as indicated by the impression.

This genus was established to receive certain species referred by some authors to the genus *Glyphocyphus*, by others to *Cyphosoma*. These species, according to M. Cotteau, are distinguished from *Glyphocyphus* by their imperforate tubercles, their horizontal sutural impressions, and less solid apical disc. Their crenulated and non-perforated tubercles bring them into near relation with certain species of *Cyphosoma*, as *C. Delamarrei* and *C. magnificum*, var. *sulcatum*, which show at the base of their inter-ambulacral plates some traces of sutural impressions; but these feeble depressions, however, cannot be compared with the deep horizontal grooves that characterize *Echinocyphus*, and impart to the few species composing this group the physiognomy of *Glyphocyphus*, with which M. Desor placed them.

Echinocyphus difficilis, *Agass.* Pl. XXII, figs. 1 *a*, *b*, 2 *a*, *b*, *c*, *d*, 4.

Cyphosoma difficile,	*Agass.* Catal. Syst. Ectyp., Mus. Neocom., p. 12, 1840.
— —	*Agassiz* et *Desor.* Catal. rais. des Échinid., Ann. Sc. Nat., 3e série, tom. vi, p. 352, 1846.
— —	*Bronn.* Index Palæontologicus, p. 381, 1848.
Diadema rotulare,	*McCoy.* Mesozoic Radiata, Ann. of Nat. History for December, 1848.
— Maccoyi,	*Forbes.* Catalogue of British Fossils, Morris, 2nd ed., p. 76, 1854.
— rotatum,	*Forbes.* Memoirs of Geological Survey, Decade V, p. 3, 1856.

Glyphocyphus difficilis,	*Desor.* Synops. des Échinides foss., p. 104, 1857.
Cyphosoma difficile,	*Woodward* (pars). Mem. of Geol. Survey, Appendix to Decade V, p. 3, 1858.
Glyphocyphus difficilis,	*Dujardin* et *Hupé.* Hist. Nat. des Zooph., Échinid., p. 513, 1862.
Echinocyphus difficilis,	*Cotteau.* Pal. Française, Ter. Crétacé, t. vii, p. 708, pl. 1174, 1866.
— rotatus,	*Cotteau* (pars). Ibid., t. vii, p. 711, pl. 1174-75.

Test small, subcircular, moderately inflated on the upper surface, flattened at the base, concave around the mouth, and rounded at the sides; poriferous zones narrow, straight, and subflexuous at the ambitus; pairs of pores in a single series; ambulacral areas narrow above, enlarged at the ambitus, with two rows of tubercles, one of which is often abortive; inter-ambulacral areas wide, having two rows of tubercles; plates possessing small, strongly radiated areolæ, and divided by deep sutural impressions; apical disc equal to the oral opening, flat, and finely granulated.

Dimensions.—Transverse diameter eight tenths of an inch; height four tenths of an inch.

Description.—This Urchin has long been mistaken for a *Diadema*, and is catalogued in some lists of Upper Greensand fossils as *D. rotatum*. Small specimens, measuring from four to five lines in diameter, are abundant in the Upper Greensand of Warminster, and may readily be distinguished from Diademas by the sutural impressions on their plates, the small radiating ribs on many of the large areolæ, and the irregularity of the two rows of ambulacral tubercles, one of which is often abortive. The larger and taller specimens agree with the published mould of Professor Agassiz's type specimen of *Cyphosoma difficile*, to which this Urchin is now referred.

Almost all the examples I have collected from the Upper Greensand are small and well preserved; the few I have from the Lower Grey Chalk are larger, and show the sculpturing of the plates better. The test is subcircular, or slightly pentagonal, moderately convex on the upper surface, flattened at the base, and rounded at the border. The poriferous zones are narrow, straight above and below, and subundulated at the ambitus. The pores are small, and form a single series of pairs throughout from the mouth to the disc (fig. 2 *d*); the pairs of pores are separated horizontally by small prominent ribs, more or less granular, which correspond to the poriferous plates, and are prolonged to the base of the tubercles. The ambulacral areas are narrow, and provided with two rows of tubercles; in some specimens from the Grey Chalk these rows are regular and the tubercles of equal size, but in many specimens from the Upper Greensand, as in figs. 2 *a*, *b*, *c*, *d*, one row becomes abortive, and the other only is developed; more than half the specimens that have passed through my hands have been thus formed. The inter-ambulacral areas are wide, with two rows of tubercles a little larger than those occupying the ambulacra; in large specimens there are ten or twelve tubercles in each row, the number depending on the age of the individual. Between the ambitus and peristome the areolas are well developed, and surrounded by

circles of large sub-elliptical granules, that are prolonged in a radiated manner towards the base of the mammillon (fig. 2 *d*). The coronal plates at their lower border are marked by a horizontal depression, as if the lower half of the plate had been scooped out (fig. 2 *a*) at the expense of a portion of the granular circle. The boss is prominent, and its summit is marked with feeble crenulations. The mammillon is always large and unperforated. The miliary zone is wide in its upper part, and the surface of the plates is covered with a very fine granulation; at the ambitus it is filled with two or three rows of large granules, which diminish below into a single series, and take a zigzag direction towards the peristome.

The small mouth-opening, about one third the diameter of the test, is lodged in a concave depression (fig. 2 *b*). The peristome is circular, and nearly equally lobed, and the incisions are slight.

The apical disc, which is very rarely preserved (Pl. XXII, fig. 4), equals the oral opening in size, and is flat and finely granulated; the cordate ocular plates are rather large, and perforated close to the ambulacral margin; the large ovarial plates are perforated, and the madreporiform body occupies the right anterior plate; the single posterior plate is wanting.

Affinities and Differences.—This species very much resembles *Cyphosoma rotatum*, Forb., of which it proves to be a variety; the irregularity of the two rows of ambulacral tubercles, one of which is often abortive, is not, according to our observations, a persistent character, and for this reason we regard *E. difficilis* and *E. rotatus* as varieties of one form. M. Cotteau, however, considers them distinct, and takes as a diagnostic character the single row of tubercles in the ambulacral areas, as this difference does not appertain to age, seeing that it is found in small as well as in large specimens. *Echinocyphus difficilis*, Ag., may be confounded with *Glyphocyphus intermedius*, Cott., which has a similar disposition of the ambulacral tubercles, only that they are perforated in *Glyphocyphus* and unperforated in *Echinocyphus*.

Locality and Stratigraphical Position.—I have several specimens which I collected from the hard Grey Lower Chalk near Folkestone, and numerous smaller examples from the Upper Greensand near Warminster; from the latter formation a very large specimen was obtained, now in the cabinet of G. E. Sloper, Esq., Devizes. The late Dr. S. P. Woodward states that it measures nine lines in diameter, and four and a half in height; both rows of ambulacral areas are well developed, and the miliary granules form a prominent framework to the tubercles.

In France, M. Cotteau records this species from the Étage Cénomanien of Vellelaire (Haute-Saône), and Présagny (Eure), where it is rare.

History.—First catalogued as *Diadema rotulare*, Ag., from Durdle Door, Dorset, by Prof. McCoy, in his 'Mesozoic Radiata,' in 1848, and afterwards by Prof. E. Forbes, as *Diadema rotatum*, from the Upper Greensand of Warminster, in the second edition of the 'Catalogue of British Fossils.'

ECHINOCYPHUS MESPILIA, *Woodward*. Pl. XXII, figs. 3 *a*, *b*, *c*, *d*.

CYPHOSOMA MESPILIA, *Woodward*. App. Decade V, Mem. of the Geol. Survey, p. 3, 1856.

Test small, circular, inflated or depressed, convex above and below, with subequal apertures; poriferous zones straight, simple, pairs of pores very oblique; tubercles nearly equal, prominent, imperforate and crenulated; areolæ small, radiated, with elongated miliary granules, sutural impressions slight; inter-ambulacra wide, with two rows of tubercles, seven to eight in each; ambulacra narrow, with seven to eight tubercles, alternate, and irregular.

Dimensions.—Height three lines; transverse diameter five lines.

Description.—This species was discovered by my late friend, Dr. S. P. Woodward, who found it in the Lower Hard White Chalk along with *Cyphosoma simplex*, Forb., and *Salenia granulosa*, Forb. It is a pretty little Urchin, with inflated sides; the test is nearly convex above and below, the poriferous zones are straight and simple, the unigeminal pores are very oblique, the ambulacral areas are narrow, and the tubercles, seven or eight in number, are alternate and irregular (fig. 3), one of the rows being partially abortive. The inter-ambulacral areas are wide, and have two rows of prominent tubercles, seven to eight in each row (fig. 3), which occupy the centre of the plates, and are surrounded by small radiated areolæ, formed by an oblique arrangement of the elongated granules thereon, and imparting an ornamented character to the test. The mouth-opening is more than one third of the diameter of the test, the peristome is nearly equally lobed, and the incisions are wide and deep. The discal opening is larger than the oral in diameter.

Affinities and Differences.—This Urchin very much resembles *E. difficilis*; it has, however, a more inflated test, with stronger radii on the areolæ, and larger oral and discal apertures. Its author considered it "a very distinct species," and called my especial attention to it. A careful comparison of the accurate figures of both species drawn on Pl. XXII will enable the student to appreciate the affinities and differences between them better than any description, however elaborate.

Locality and Stratigraphical Position.—*E. mespilia* has been collected only from the Lower Chalk, in the hard beds of which it has been found, associated with *Cyphosoma simplex* and *Salenia granulosa*. The only specimens I have seen are in the British Museum.

Genus—Glyphocyphus, *Haime*, 1853.

Arbacia (pars), *Agassiz*, 1836.
Echinopsis (pars), *Agassiz*, 1846.
Hemidiadema, *Agassiz*, 1846.
Temnopleura (pars), *Sorignet*, 1850.
Glyphocyphus, *Jules Haime*, 1853.
— *Desor*, 1856.
— *Cotteau*, 1859.

The Urchins forming this group have a small circular test, more or less inflated above and concave below. The poriferous zones are straight, depressed, and composed of unigeminal pores throughout. The primary tubercles of both areas are nearly of the same size. The boss, with its crenulated summit, is surrounded by a distinct areola, and surmounted by a small mammillon minutely perforated at the vertex. The ambulacral and inter-ambulacral plates are marked with sutural depressions, which are wider and deeper on the plates of the latter areas; the surface is covered with fine, close-set homogeneous granules, nearly uniform in size over the whole test (Pl. XXIX B, figs. 1 and 2). The apical disc is a small annular structure, solidly united to the test, and forming a narrow, slightly elongated, oblong ring, composed of five ovarial and five ocular plates, articulated alternately together on the same line around the vent aperture or periprocte (fig. 2 *b*). The ovarial plates are the largest; they have a triangular shape, with tubercles external to the annulus, and a large hole at the apex; the right antero-lateral plate is the largest, and supports the madreporiform body. The rhomboidal ocular plates are wedged in alternately on the same line with the ovarials; and the portion external to the annulus is covered with numerous granules. Mouth-opening is small, subcircular, and sunk in a slight depression; peristome decagonal, divided into lobes by feeble incisions.

The genus *Glyphocyphus* forms among the Diademadæ with crenulated and perforated tubercles a very small group, in which the ambulacral and inter-ambulacral plates are marked with angular impressions, and their surface covered with prominent close-set granulations. The solidity of the apical disc, and its firm articulation to the coronal plates, with the regularity as regards size and arrangement of the tubercles in both areas, form an assemblage of characters which readily distinguish the small Urchins of this group from their congeners. A considerable difference of opinion has prevailed amongst Echinologists regarding the true characters of the forms now comprised in this genus, arising, doubtless, from the smallness of the individuals themselves, the imperfect preservation of most of the specimens, and the destruction of many of the essential structures that distinguish them. M. Cotteau, however, had lately at his disposal a fine series of

beautiful and perfect specimens of *Glyphocyphus radiatus*, collected by the late M. Triger from the Terrain Crétacé of the department of the Sarthe, and from the study of these M. Cotteau has been enabled to clear up doubts that had previously existed regarding the structure of many of the species. This genus is nearly allied to *Echinocyphus*, which presents a similar facies of lateral impressions on the ambulacral and inter-ambulacral plates, but is distinguished from it by having the mammillons of the tubercles perforated, whereas in *Echinocyphus* they are imperforate. The apical disc is, likewise, solidly united to the coronal plates in *Glyphocyphus*, but slenderly so in *Echinocyphus*. M. Agassiz proposed the genus *Hemidiadema* for Urchins differing from the Diademas in one character, that the ambulacral areas possessed only a single row of tubercles, and cited as the type of this group *Hemidiadema rugosum*, Agass., from the Upper Greensand (Étage Cénomanien) of Grandpré, Ardennes, a small species having the ambulacral tubercles as large and even larger than the inter-ambulacrals; this Urchin, it now appears, is a true *Glyphocyphus*, with a single row of tubercles in its ambulacral areas—a character which is only specific, and not generic, as far as we at present know.

The genus *Echinopsis*, Agass., in which certain species of *Glyphocyphus* have been placed, consists, according to its author, of "small, subconical, inflated Urchins, with the ambulacra nearly as large as the inter-ambulacra, and both ornamented with tubercles perforated but not crenulated. Mouth small, with feeble incisions, differing from the Diademas by the absence of crenulations on the tubercles." To this genus was referred *Echinopsis contexta*, Ag., *E. latipora*, Ag., *E. depressa*, Ag., all of which are forms of *Glyphocyphus radiatus* and *Glypticus Koninckii*, Forb. *Echinopsis pusilla*, Roem., and *Temnopleurus pulchellus*, Coquand, must now likewise be added to the list.

GLYPHOCYPHUS RADIATUS, *Hœninghaus*. Pl. XXIX B, figs. 1, 2, *a*, *b*, *c*, *d*, *e*.

ECHINUS RADIATUS,	*Hœninghaus* in *Goldfuss*. Petref. Germaniæ, p. 124, tab. xl, fig. 13, 1826.
— —	*Agassiz*. Prod., Mém. Soc. Nat. des Sc. de Neufchâtel, t. i, p. 196, 1836.
— —	*Desmoulins*. Études sur les Échinides, p. 292, No. 55, 1837.
ECHINOPSIS LATIPORA,	*Agassiz*. Catal. Syst. Ectyp. foss., Mus. Neoc., p 9, 1840.
— CONTEXTA,	*Agassiz*. Ibid.
— DEPRESSA,	*Agassiz*. Ibid.
ECHINUS RADIATUS,	*Dujardin*. In Lamarck's Anim. sans Vert., 2e éd., t. iii, p. 371, 1840.
ARBACIA RADIATA,	*Roemer*. Norddeutschen Kreidegebirges, p. 30, 1840.
ECHINOPSIS PUSILLA,	*Roemer*. Ibid., pl. vi, fig. 10, 1840.
CYPHOSOMA RADIATUM,	*Agassiz* et *Desor*. Ann. Sc. Nat., 3e série, t. vi, p. 352. Cat. rais. des Échinides, 1846.

Echinopsis latipora,	*Agassiz* et *Desor.*	Ibid., p. 351, 1846.
— contexta,	*Agassiz* et *Desor.*	Ibid.
— depressa,	*Agassiz* et *Desor.*	Ibid.
— contexta,	*Bronn.*	Index Palæontologicus, p. 447, 1848.
— depressa,	*Bronn.*	Ibid.
— latipora,	*Bronn.*	Ibid.
— pusilla,	*Bronn.*	Ibid.
Arbacia radiata,	*Bronn.*	Ibid., p. 91, 1848.
Temnopleurus pulchellus,	*Sorignet.*	Ours. fossiles du Dép. de l'Eure, p. 31, 1850.
Glypticus Koninckii,	*Forbes.*	In Dixon's Geology of Sussex, p. 340, tab. xxv, fig. 30, 1850.
Echinopsis pusilla,	*Forbes.*	In Dixon, ibid., tab. xxv, fig. 31, 1850.
— —	*Giebel.*	Deutschlands Petrefacten, p. 320, 1852.
Glyphocyphus pulchellus,	*d'Archiac* et *Jules Haime.*	Descript. Nummilites de l'Inde, p. 202, 1854.
Echinopsis pusilla,	*Morris.*	Catal. of Brit. Fossils, 2nd. ed., p. 78, 1854.
— latipora,	*Pictet.*	Traité de Paléontol., 2e éd., p. 242, 1846.
— contexta,	*Pictet.*	Ibid.
— depressa,	*Pictet.*	Ibid.
— pusilla,	*Pictet.*	Ibid.
Cyphosoma radiatum,	*Pictet.*	Ibid.
Glyphocyphus radiatus,	*Desor.*	Synopsis des Échinides fossiles, p. 103, tab. xvii, figs. 1—3, 1856.
— —	*Cotteau* et *Triger.*	Échinides du dép. de la Sarthe, p. 185, pl. xxviii, figs. 7—12, 1859.
— —	*Dujardin* et *Hupé.*	Hist. nat. des Échinod., p. 513, 1862.
Temnopleurus pulchellus,	*Coquand.*	Géol. et Pal. de la prov. de Constantine, p. 294, 1863.
Glyphocyphus radiatus,	*Cotteau.*	Paléont. Franç., Ter. Crétacé, t. vii, p. 535, pl. 1127, 1128, 1863.

Test small, circular, inflated, subglobular, rounded at the border and concave at the base; ambulacra very narrow, with two rows of tubercles, alternate, irregular. Poriferous zones narrow, straight; simple pores in single oblique pairs. Inter-ambulacra with two rows of small tubercles, areolæ radiated, plates grooved at the lower border; apical disc solid, forming a narrow, elongated, subpentagonal ring, having the genital and ocular plates almost of equal length; oculars finely granulated; vent large, oblong.

Dimensions.—Height five twentieths of an inch; transverse diameter eight twentieths of an inch.

Description.—This small Urchin has been a great puzzle to Palæontologists, as proved by the long list of synonyms given above. The test is circular, inflated, and subglobular; rounded at the sides, and concave towards the base (figs. 1 *a*, *b*). The ambulacral areas (fig. 2 *c*), about half the width of the inter-ambulacral, have two rows of small tubercles, which form an alternate series on each side of the area; they are largest at the ambitus, smaller

at the base and upper surface; they are feebly developed throughout, and finely perforated at the summit; the areolæ are regularly spaced out and placed on the border of the poriferous zones, which are straight, slightly depressed, and formed of small round pores, disposed in single oblique pairs throughout, from the peristome to the disc; the pairs of pores are separated from each other by a horizontal granular ridge of the test, which is more or less apparent in different specimens; in some examples one of the rows of tubercles becomes abortive; the surface of the area is filled in with numerous small granules, and the ambulacral plates are slightly marked with impressions on the line of the median suture. The inter-ambulacral areas, fig. 2 *d*, are double the width of the ambulacral, and provided with two rows of tubercles, similar in structure to, but larger in size than, those of the ambulacra: the areolæ occupy the centre of the plates, and are surrounded with a close-set granulation: two of the granules, elongated in a vertical direction, unite the contiguous areolæ, which imparts a moniliform character to well-preserved tests of this pretty little Urchin; the plates are marked with impressions more or less deep at the inner and outer angles, and on each side of the vertical filament at the lower part of each plate (fig. 1 *c*, fig. 2 *c*).

The mouth-opening is small, situated in a slight depression, and the peristome is delicately incised into ten unequal lobes (fig. 2 *a*).

The vent is large, sub-elliptical in shape, and contracted behind; the apical disc forms a narrow, elongated, subpentagonal ring, somewhat peculiar in its structure, for instead of the small ocular plates being wedged in between the larger genitals, they are arranged alternately with them on the same line, and form a strong ring around the elliptical vent; the genital plates are a little larger than the oculars, and have two small tubercles on their surface; the oculars are covered with a fine granulation, and the madreporiform tubercle is conspicuous by its spongy surface (fig. 2 *b*).

This Urchin varies much in size; the specimens figured by Goldfuss, Desor, and Dixon, with those I possess, are all small. M. Cotteau has given elaborate details of a larger specimen found in the Department of the Sarthe, in which the characters of the test are admirably exhibited; they are beautifully figured, both in his fine plates on the Échinides of the Sarthe, and likewise in those in the 'Paléontologie Française,' some of which I have copied in Pl. XXIX B, as none of my specimens have the characters so well preserved as in the perfect fossil test figured by my friend.

Affinities and Differences.—*Glyphocyphus radiatus* is so rare an Urchin in the English Chalk that it is not likely to be mistaken for any other. It is smaller and more globular than *Echinocyphus difficilis*, which it most resembles, and has the tubercles perforated, the miliary zone wider and more granular, the disc smaller and more solidly united to the coronal places than in any *Echinocyphi*.

From a careful examination of the ample materials at his disposition, M. Cotteau concludes that the large examples forming the type of the species represent *Echinocyphus conferta*, Ag., and exhibit natural impressions either deep and angular or linear and attenuated. Some specimens, less inflated, and possessing a stronger development of the

vertical filament form *E. latipora*, Ag., and depressed examples with the median impression almost absent are *E. depressa*, Ag. A careful study of the original types has, however, convinced my learned friend that they are all varieties of one form, and not distinct species.

Locality and Stratigraphical Position.—This species is found very rarely in the hard beds of the Lower Chalk near Lewes, in Sussex, and in the Grey Chalk near Folkestone. From this stratum my best specimen was collected by Captain Cockburn, R.A., to whose kindness and liberality I am indebted for the example.

The Foreign Localities given by M. Cotteau are Villers-sur-Mer, Bruneval, Saint-Jouin, Vaches-Noires, Dives (Calvados); Fécamp, le Havre, Rouen (Seine-Inférieure): Gacé, La Perrière (Orne); Nogent-le-Bernard (Sarthe); Saint-Fargeau (Yonne); la Bedoule, Cassis (Bouches-du-Rhône). In all these localities it is very rare, and occurs in the Etage Cénomanien, in the zone of *Scaphites æqualis*, which is the equivalent of the English Lower Grey Chalk.

History.—This species was found in the Lower Chalk of Essen and Gehrden, Westphalia, and was first figured and described by Goldfuss in his 'Petrefacta Germaniæ.' Since that time it has passed through a series of changes which are most correctly read in the long list of synonyms introductory to this article, and to which I commend the reader's especial attention.

Genus—Echinothuria,[1] *Woodward*, 1863.

"*Test* globular?, diameter of compressed specimen four inches, thickness half an inch, lantern projecting half an inch; composed of ten segments or double series of imbricating plates, ornamented with obscure miliary granules and small spine-bearing tubercles, a few larger than the rest; *inter-ambulacral* plates narrow, slightly curved, with the convex edge upwards and overlapping; the alternate plates bearing one large extero-lateral tubercle, perforated, and surrounded by a raised ring and smooth areola; largest plates measuring six lines in length, the smallest three lines or less (the longest in second specimen equalling seven lines); *ambulacral* plates seven lines long, equalling the breadth of the exposed portion of eight plates, similar to the former, but curving and imbricating downwards towards the dental orifice, and having two small plates, each perforated by a pair of pores, intercalated in a notch of the middle of the lower margin; a third pair of pores perforating the plate itself a little external to the centre; primary tubercles few, irregularly distributed.

[1] "Etymologists need not trouble themselves about the derivation of this name; it is intended merely to express the dilemma in the writer's mind, arising from imperfect knowledge, but which he believes to have no foundation in nature."—'Geologist,' vol. vi, p. 330.

"*Spines* of three kinds; those adhering to the plates minute and striated; fragments of larger spines (not certainly belonging to the species) striated, annulated, and furnished with a prominent collar to the articular end (fig. 4); the third kind minute, clavate, and truncate, articulated to a slender stalk" (fig. 5).

ECHINOTHURIA FLORIS, *Woodward*.[1]—Pl. XXIX B, figs. 3—5.

ECHINOTHURIA FLORIS, *Woodward*. 'Geologist,' vol. vi, pp. 327—330, 1863.

"The fossils represented" in Pl. XXIX B "are probably only fragments of the original structure, and possibly only the smaller and less essential portions of the whole. Nevertheless, I have determined to publish some account of them, although at the risk of committing an extravagant error, as a last resort towards obtaining more complete examples or suggestions for their more correct interpretation.

"Both specimens have been presented to the British Museum; one by J. Wickham Flower, Esq., of Park Hill, Croydon, the other by the Rev. Norman Glass, of London.

"The first example was obtained, at least sixteen years ago, from the Upper Chalk of Higham, near Rochester, and was submitted to Professor E. Forbes, in whose custody it remained for several years. It was originally shown to me in connection with the anomalous Cirripede *Loricula*, then newly discovered by Mr. Wetherell. The resemblance between them is certainly curious; but there is no real relationship. Mr. Flower's fossil exhibits distinct traces of the crystalline structure peculiar to petrified Echinodermata, and the pairs of pores in the ambulacral plates are equally characteristic of the Echinidæ. Mr. Darwin also has examined this fossil and rejected it from his province of inquiry.

"Professor Forbes could not make up his mind to describe the specimen, and ultimately it was returned to Mr. Flower, with whom it remained until the publication of a note on the genus *Proto-echinus*, by Major Thomas Austin, in the 'Geologist' for 1860 (vol. iii, p. 446), when it was entrusted to me for the purpose of considering whether it had any special affinity with this new type, and for description in the same journal.

"The *Proto-echinus* was obtained from the Carboniferous Limestone of Hook Head, Wexford, and is but a fragment of a single ambulacrum, consisting of three series of plates at the wider end and two at the other extremity, with apparently a single terminal

[1] 'On *Echinothuria floris*, a new and anomalous Echinoderm from the Chalk of Kent.' By S. P. Woodward, F.G.S. I have printed this paper from the 'Geologist' entire (altering the references to figures), as a contribution to British Echinology by my late esteemed friend. Dr. Woodward took so warm an interest in my work, and afforded me such valuable assistance, by the loan of specimens for figuring, that it affords me very great pleasure to acknowledge here his uniform kindness, and connect his name with a Monograph to which he contributed important aid.

plate. Each plate is perforated by a pair of pores. It differs from *Echinothuria* in every particular.

"The question presented to me by Mr. Flower's fossil was, whether to consider it part of the envelope of a new kind of *Holothuria*, or whether it might be no more than a fragment of the oral disc of some great unknown *Echinus*. Portions of the imbricating scaly armour of a *Psolus* had been met with when examining the fossils of the Boulder Clay collected by Mr. J. Richmond, of Rothsay; but in *Psolus*, while the greater part of the body is clothed with fish-like scales, the ambulacra are only developed on one side, forming a creeping disc, the scales of which are small and not imbricated. On the other hand, the peristome of the largest known Echinite from the Chalk is less than an inch in diameter; and the largest recent Sea-urchin in the Museum has an oral disc not more than two inches wide, whereas the fossil is a segment of a disc which must have been at least four inches across. This objection, on the score of size, was, however, less felt, because the Cyphosomas and Diademas of the Chalk have larger oral and apical orifices than any other Urchins, and the character of their apical disc was unknown, being only preserved in a few minute specimens of *C. difficile*, from Chute Farm. Moreover, there were indications in the Upper Chalk of a great *Diadema*, of which nothing more had been obtained than scattered plates and fragments of spines. This species is referred to in Decade V of the 'Geological Survey' (Article "Diadema," Section C, spines tubular, annulated). Mr. Wetherell obtained a mass of Chalk containing above one hundred fragments of spines, which are hollow, striated and annulated, as in the recent *D. calamaria*. From the plates mingled with the spines we ascertained that the ambulacral pores presented the usual characters, being arranged in single file, and a little crowded near the peristome; but many of the plates presented only their smooth inner surfaces. A smaller mass of Chalk, in Mr. Wiltshire's cabinet, contains similar plates and spines, mingled with a few true scales and minute truncated spines like those of *Echinothuria*. The Diadema spines were erroneously referred by Professor E. Forbes to the genus *Hieraster* (Decade III, pl. 10, fig. 15; bad, for they are not spiral). They are also figured by Dixon, in his 'Geology of Sussex,' and described by Forbes as "spines of a Cidaris." Diademas possessing spines of this character are known to occur in the Upper Cretaceous strata of France; and Dr. Wright has lately obtained a small specimen from the Chloritic Marls of Dorsetshire. In these the apical disc is quite small.

"A more serious difficulty, in comparing Mr. Flower's fossil with the oral disc of any Echinite, was presented by the arrangement of the plates; in the recent Echinidæ . . . . . they are all directed towards the dental orifice, but here the alternate series take opposite 'dips,' the ambulacral plates overlapping one way and the others in a contrary direction.

"Last year, while I was still hesitating about the publication of Mr. Flower's fossil, a second specimen was obtained from Charlton, in Kent, by the Rev. N. Glass, who has cleared it from the matrix with great skill and patience. . . . . At first sight this specimen would seem to solve the problem, by supplying the peristome and lantern of the same

great *Cyphosoma* or *Diadema*, of which Mr. Flower's specimen might be the apex or periproct. But a closer examination confirms the objections already stated, and gives increasing probability to the other conjecture (if, indeed, it does not compel us to adopt it), however difficult it may be to realise the notion of an Echinite having no proper 'test,' and clothed entirely with imbricating scales like those of the peristome of *Cidaris*.

"In Mr. Flower's specimen the imperforate plates imbricate towards the centre (or apex), where the smaller ends of the several series converge. In Mr. Glass's specimen they slope away from the centre (or mouth), that is, also towards the apex. The perforated or ambulacral plates, which overlap one another outwardly (*i. e.* downwards) in specimen, fig. 3 *a*, are seen sloping towards the dental cone and reclining upon it. The portion of an ambulacrum, fig. 5 *a*, consists of four plates, diminishing in size from *c* to *a*, in a line not accurately directed towards the centre. This portion exhibits the *interior* surface of the plates, known by their curved surfaces, destitute of ornamental granules; it is not, however, the oral end of one of the segments turned over, a thing scarcely possible to happen, for in that case the dip of the plates would be reversed; but it must be the opposite (or apical) extremity of a series folded back upon its origin, and exposed to view by the damage which the surface of the specimen has sustained. From this circumstance it seems probable that the whole fossil, when complete, was not elongated, nor even spherical, but somewhat depressed in a vertical direction, though doubtless admitting of a moderate amount of flexure. At the last hour, after making the drawing, I ventured to clear away the chalk from the side of Mr. Glass's fossil, near where an ambulacral segment is seen to curve as if it might be continued round to the other surface. This attempt was successful, for the ambulacrum and also the adjacent inter-ambulacral segment were found continuous, though crowded and displaced at the turning, falling again into regular order, and diminishing in size, though not so nearly complete as in Mr. Flower's example.

"After this apparently conclusive demonstration, it appears desirable to give a name to the fossil, and to attempt a short description, although its rank and affinities are to us still matter of conjecture. At present it is one of those anomalous organizations which Milne-Edwards compares to solitary stars, belonging to no constellation in particular. The disciples of Von Baer may regard it as a 'generalised form' of Echinoderm, coming, however, rather late in the geological day. The publication of it should be acceptable to those who base their hopes on the 'imperfection of the geological record,' as it seems to indicate the former existence of a family or tribe of creatures whose full history must ever remain unknown."

Locality and Stratigraphical Position.—Collected from the Upper Chalk of Higham, near Rochester. The fine specimens in the Rev. T. Wiltshire's cabinet were obtained from the Upper Chalk at Gravesend and Charlton.

Genus—Cyphosoma, *Agassiz*, 1840.

Cyphosoma, *Agassiz*, 1840.
Phymosoma, *Haime*, 1853.
— *Desor*, 1858.
Cyphosoma, *Cotteau*, 1863.

Test moderate in size, circular or subpentagonal, slightly inflated at the sides. Poriferous zones well developed and undulated, composed of simple pores that in general are unigeminal throughout, and sometimes are bigeminal on the upper surface, and crowded a little together around the peristome. The poriferous plates are unequal and irregular in their mode of arrangement. The primary tubercles are nearly equal in size in both areas, the areolæ are well developed, and sometimes marked with radiated striations; the bosses are prominent, and have their summits sharply crenulated; the mammillon is large, prominent, and imperforate, and the general facies of the test shows a regular, and uniform development of all its several elements. The mouth-opening is large, the peristome slightly incised, and the oral lobes nearly equal. The discal opening is large and pentagonal, one angle of which extended far into the single inter-ambulacrum; the elements of the disc were feebly united, as they are absent in all the specimens that have hitherto been collected.

The spines are long, solid, subcylindrical, aciculate, or spatuliform; sometimes they are straight and lanceolate, or bent, ramiform, or spoon-shaped; all these varieties are figured in Pls. XXIV and XXVI. The stem is smooth and marked with fine longitudinal striæ, the milled ring is prominent, the head distinct, and the rim of the acetabulum crenulated.

The genus *Cyphosoma* is distinguished from all others by its prominent tubercles with crenulated bosses, and imperforate mammillons; in the structure of these it resembles *Echinocyphus* and *Temnopleurus*, but is readily distinguished from these by the absence of the angular and sutural impressions which impart so marked a character to their tests.

M. Desor has separated into the genus *Coptosoma* all those *Cyphosomata* from the Nummulitic formation (Tertiary) with much undulated poriferous zones, tubercles with very large mammillons, and having the plate-sutures of the areas deeply incised; thus leaving the typical *Cyphosomata* as true Cretaceous fossils, which first appear in the Neocomian beds, and attain their maximum development in the upper stage of the White Chalk.

The Cretaceous rocks of France are very rich in species of *Cyphosoma*, of which a very small proportion have hitherto been found in the British islands.

A.—*Species from the Lower Chalk.*

CYPHOSOMA GRANULOSUM, *Goldfuss*, sp., 1826. Pl. XXIII, figs. 2 *a*, *b*, *c*, *d*.

CIDARITES GRANULOSUS,	*Goldfuss.*	Petrefact. Germaniæ, pl. xl, fig. 7, p. 122, 1826.
DIADEMA GRANULOSUM,	*Agassiz.*	Prod., Mém. Soc. des Sc. Nat. de Neufchatel, t. i, p. 189, 1836.
ECHINUS MILLERI,	*Desmoulins* (pars).	Études sur les Échinides, p. 294, No. 68, 1837.
ECHINUS GRANULOSUS,	*Dujardin.*	In Lamarck's Anim. sans Vertébres, 2e éd., t. iii, p. 372, 1840.
CIDARITES GRANULOSUM,	*Geinitz.*	Charakt. der Schict. und Petref., p. 90, 1842.
DIADEMA —	*Morris* (pars).	Catalogue of British Fossils, p. 51, 1843.
CYPHOSOMA —	*Reuss.*	Verstein. der Böhm. Kreideform., p. 58, 1846.
— MILLERI,	*Agassiz* et *Desor* (pars).	Catalogue rais. des Échinid., p. 351, 1848.
— —	*Bronn.*	Index Palæontologicus, p. 381, 1848.
— —	*D'Orbigny.*	Prod. Pal. strat., t. ii, p. 273, Ét. 22, 1850.
— —	*Bronn.*	Lethæa Geognost., Kreide-gebirges, pl. xxix, p. 186, 1851.
— KÖNIGI,	*Forbes.*	In Morris's Catalogue of British Fossils, 2nd ed., p. 75, 1854.
PHYMOSOMA GRANULOSUM,	*Desor.*	Synops. des Échinid. foss., p. 87, 1856.
CYPHOSOMA —	*Woodward.*	Mem. Geol. Surv., Dec. V, p. 1, 1857.
PHYMOSOMA —	*Hupé.*	Hist. Nat. Échinod., p. 508, 1862.
CYPHOSOMA —	*Cotteau.*	Pal. Française, Ter. Crétacé, t. vii, p. 685, pl. 1169, 1865.

Test large, circular, depressed, convex on the upper surface, inflated at the sides, and flattened below; poriferous zones wide and straight in the upper third, narrow and undulated at the ambitus and base; pores largely bigeminal in the wide upper third, and unigeminal in the rest of the zones; ambulacra narrow above, wide below, with two rows of large tubercles, twelve in each; inter-ambulacra with two rows of primary tubercles in the middle of the area, secondary tubercles wanting in young specimens, and only slightly developed in the largest tests; miliary zone wide, depressed, and naked above, narrow and granular below; mouth-opening small and circular; peristome with shallow entailles: discal opening large, and widely pentagonal.

Dimensions.—Height eight tenths of an inch; transverse diameter one inch and eight tenths.

Description.—This Urchin resembles *C. Königi* in so many points of structure, the absence or rudimentary condition of the secondary tubercles excepted, that it may probably be only a variety of that species. It has, however, been treated by different sys-

tematic authors as specifically distinct; and in deference to their opinion, rather than in accordance with my own convictions, I have devoted this article to its description.

The test large and circular, inflated at the ambitus, convex above, and flat below (Pl. XXIII, figs. 2 *a*, *b*, *c*).

The ambulacral areas are enlarged at the ambitus, moderately wide at the base, and very narrow in the upper part; by reason of the increased development of the poriferous zones in this region, from the ambitus to the peristome, the tubercles are as large as those in the inter-ambulacra, but in the upper third of the area they diminish rapidly in size, and on the four or five coronal plates they are quite rudimentary (Pl. XXIII, fig. 2 *a*). The pores are arranged in oblique pairs, and are bigeminal from the ambitus to the summit (Pl. XXIII, fig. 2 *c*, *d*), and unigeminal from the ambitus to the peristome, the zones forming a series of crescents around the areolæ of the ambulacral tubercles.

The inter-ambulacral areas have two rows of primary tubercles, twelve to thirteen in each row, which vary gradually in size from the ambitus to both apertures; they are surrounded by well-developed areolæ, confluent at the upper and lower borders, and surrounded by granules at the sides. The secondary tubercles are irregular, very small, and limited to the under surface (fig. 2 *b*). On one or two plates above the ambitus there are only one or two solitary tubercles, which are, however, inconstant in different specimens (fig. 2 *d*). The miliary zone is narrow and granular at the ambitus, and wide, depressed, and naked on the upper surface; the granules are unequal, of different sizes, and placed in semicircular groups around the lateral parts of the areolæ. Many of the granules are large and mammillated, and are nearly as large as the row of secondary tubercles, the small granules being compactly fitted in between them. The coronal plates are marked by slight sutural impressions, which become more apparent in consequence of the nudity of the depressed upper surface of the areas.

The discal opening is very large, pentagonal, and angular; and the single posterior ovarial plate is projected far into the area (fig. 2 *a*). The mouth-opening is moderate in diameter (fig. 2 *b*); the peristome is circular, and divided into ten unequal lobes by slight incisions with reflexed borders.

Affinities and Differences.—This species differs from the typical forms of *Cyphosoma Königi* in the absence of a regular series of secondary tubercles above the ambitus; but in the general character of the test and in most of its details it has close affinities with that species. Whether the spines of this Urchin exhibit any difference from those attached to the typical form of *C. Königi* (Pl. XXIV, fig. 1) remains to be determined by those who may be fortunate enough to discover a specimen with the spines adherent to the test.

Locality and Stratigraphical Position.—This Urchin is found in the Lower Chalk of Kent and Sussex. The specimen figured in Pl. XXIII, belonging to the British Museum, was collected near Lewes.

Foreign Localities.—Houguemarre (Eure), Orglande (Manche), from the Étage Sénonien, where it is rare (M. Cotteau); the type of Goldfuss's figure was collected from the Chalk of Westphalia.

B.—*Species from the Upper Chalk.*

CYPHOSOMA KÖNIGI, *Mantell.* Pl. XXIII, figs. 1, 2; Pl. XXIV, figs. 1—7; Pl. XXV, fig. 3; Pl. XXVI, fig. 1.

ECHINITE.	*Parkinson.* Organic Remains, vol. iii, pl. i, fig. 10, 1811.
CIDARIS KÖNIGI,	*Mantell.* Geology of Sussex, p. 180, 1822.
ECHINUS MILLERI,	*Desmarest.* Oursins fossiles, Dict. Sc. Nat., t. xxxvii, p. 101, 1825.
CIDARITES VARIOLARIS,	*Goldfuss.* Petref. Germaniæ, p. 123, pl. xl, figs. 9 *a*, *b*, 1826.
ECHINUS KÖNIGI,	*Fleming.* British Animals, p. 479, 1828.
CIDARITES KÖNIGI,	*Brongniart.* Tableau des Terrains, p. 405, 1829.
ECHINUS KÖNIGI,	*Woodward.* Synopt. Tab. of Brit. Organ. Rem., p. 6, 1830.
— —	*De Blainville.* Zoophytes, Dic. Sc. Nat., t. lx, p. 210, 1830.
— MILLERI,	*De Blainville.* Ibid.
— —	*Agassiz.* Prod., Mém. Soc. Sc. Nat. de Neufchatel, t. i, p. 190, 1836.
— —	*Desmoulins.* Études sur les Échinides foss., p. 294, No. 68, 1837.
DIADEMA KÖNIGI,	*Desmoulins* (pars). Ibid., p. 312, No. 10, 1837.
CYPHOSOMA MILLERI,	*Agassiz.* Catal. Syst. Ectyp., p. 11, 1840.
DIADEMA GRANULOSUM,	*Morris.* Catalogue of British Fossils, p. 51, 1843.
CYPHOSOMA MILLERI,	*Agassiz* et *Desor* (pars). Catal. rais. des Échinides, p. 351, 1846.
— ORNATISSIMUM,	*Agassiz* et *Desor.* Ibid., p. 352, 1846.
— MILLERI,	*Graves.* Essai Topogr. Géognost. Dép. l'Oise, p. 688, 1847.
— MAGNIFICUM,	*Graves.* Ibid.
DIADEMA KÖNIGI,	*Bronn.* Index Palæontologicus, p. 418, 1848.
CYPHOSOMA MILLERI,	*Bronn* (pars). Ibid., p. 381, 1848.
— —	*D'Orbigny.* Prodrom. de Pal. strat., t. ii, p. 273, 1850.
— ORNATISSIMUM,	*D'Orbigny.* Ibid., t. ii, p. 273, 1850.
— MILLERI,	*Forbes.* In Dixon's Geol. of Sussex, pl. xxv, figs. 17, 26, 27, 1850.
— VARIOLARIS,	*Forbes.* Ibid., pl. xxv, fig. 29, 1850.
ECHINUS KÖNIGI,	*D'Archiac.* Hist. des Progr. de la Géol., t. iv, p. 20, 1851.
CYPHOSOMA KÖNIGI,	*Forbes.* Morris, British Fossils, 2nd ed., p. 75, 1851.
— ORNATISSIMUM,	*Forbes.* Ibid.
PHYMOSOMA KÖNIGII,	*Desor.* Synopsis des Échinides fossiles, p. 86, 1856.
CYPHOSOMA KÖNIGI,	*Pictet.* Traité de Paléontologie, 2e éd., t. iii, p. 243, 1857.
— ORNATISSIMUM,	*Pictet.* Ibid.

Cyphosoma Königi,		*Woodward.* Mem. Geol. Surv., Decade V, Appendix, 1857.
Phymosoma	—	*Dujardin* et *Hupé.* Hist. Nat. des Zooph., p. 508, 1862.
Cyphosoma	—	*Woodward.* "On König's Sea-urchin," Geologist, vol. v, p. 41, 1862.
—	—	*Cotteau.* Paléontologie Française, t. vii, p. 678, pl. 1167, 1168, 1863.

Test large, subcircular, depressed, convex on the upper surface, inflated at the sides, almost flat on the under surface; poriferous zones wide and straight in the upper third, narrow and undulated at the ambitus and base; pores bigeminal in the upper third, unigeminal in the lower two thirds of the zone; ambulacra narrow above, wider below, with two rows of large tubercles, twelve in each; inter-ambulacra with two regular rows of primary tubercles in the middle, and two rows of secondary tubercles, irregular in size and distribution, on the zonal sides of the area; miliary zone wide, naked, and depressed above, narrow and granular below; mouth-opening small, peristome circular, lobes nearly equal; discal opening large, pentagonal; spines long, subcylindrical; upper third of the stem aciculate, spatulate, straight or bent; lower third sculptured with fine longitudinal lines.

Dimensions.—Height seven tenths of an inch; transverse diameter two inches.

Description.—This is one of the largest, most beautiful, and typical of our British Cyphosoma; it was well figured by Parkinson, 1811, in his 'Organic Remains,' as "an Echinite from Kent with its spine;" he gave no description of the specimen, and it was reserved for Dr. Mantell, 1822, to give it a specific place among our Cretaceous Urchins.

The long list of synonyms prefixed to this article exhibits the historical phases through which it has passed, and the numerous admirable and accurate drawings with which our excellent friend Mr. C. R. Bone has enriched our Monograph will make the determination of *Cyphosoma Königi* a matter of ease and certainty to all future observers.

The specimen figured Pl. XXIII, figs. 1 *a*—*g*, belongs to the British Museum. The large test is subcircular, slightly convex above, inflated at the sides, and flattened below (fig. 1 *e*); the surface is highly ornamented, the tubercles are nearly all of the same size and regular in their disposition, and the granules are large and conspicuous at the base.

The ambulacral areas are narrow above, wide at the ambitus, and contracted at the base; they possess two rows of tubercles, 12 or 13 in each row; those at the ambitus are very large, and nearly equal in size the inter-ambulacral tubercles; on the upper third of the area they diminish rapidly in magnitude, and from the ambitus to the peristome are much larger.

At the ambitus the areolæ are wide and confluent, but on the upper surface they are narrow and separated only by a line of granules; the zone which divides the two series is

contracted, and provided with two rows of granules closely set together, unequal in size, some of them being mammillated at the angles of the plates.

The poriferous zones are narrow and undulated at the base and ambitus, and wide and straight at the upper surface; the pores are small, and unigeminal from the peristome to the ambitus (fig. 1 *e*), and distinctly bigeminal on more than the upper third of the zones (fig. 1 *d*); near the peristome the pairs are doubled (fig. 1 *g*).

The inter-ambulacral areas are about one third wider than the ambulacral, and furnished with primary and secondary tubercles: the primary series consists of two rows, twelve in each, occupying the centre of the plates; the tubercles are smaller on the upper than on the lower third of the area; the secondary tubercles are large and unequal in size; they form a series between the poriferous zones and primary tubercles, some of which they resemble in magnitude, especially those extending from the ambitus to the coronal plates; between the ambitus and peristome they are much smaller, and in many specimens are not more developed than large granules on mammillated eminences.

The miliary zone is very wide, naked, and depressed at the upper surface, becoming gradually narrower at the ambitus, and much contracted at the base; the granules, unequal in size, are fine, abundant, set closely together, and arranged in semicircles around the primary and secondary tubercles; some of the granules, much larger than the others, are set on mammillated eminences, and may easily be mistaken for the small secondary tubercles placed near them; this mingling together of small tubercles and large mammillated granules imparts a highly ornamented character to the infra-marginal region of this species.

Discal opening large, pentagonal, and subangular, the elements wanting in all the specimens hitherto found. Mouth-opening small, circular, the peristome feebly incised, the border reflected, the entailles having the border elevated and opening upwards.

The spines exhibit some remarkable variations from the typical form of structure. Some of the most curious of these I have figured in Pls. XXIV and XXVI. The typical spines, as seen in those *in situ* in the specimen belonging the British Museum (Pl. XXIV, fig. *a*), are elongated, subcylindrical, and sometimes aciculate at the summit (fig. 1 *d*, and fig. 3 *a*), or spatuliform with carinæ, as Pl. XXIV, fig. 1 *c*, or spoon-shaped, as Pl. XXVI, figs. 1 *a*, *b*, the lower part or collerette being long and distinct, and covered with fine longitudinal lines (Pl. XXIV, fig. 3 *b*), much stronger than those observed on the stem; the head is well developed, the milled ring very prominent, flat, and deeply striated, and the rim of the acetabulum finely crenulated (Pl. XXVI, figs. 1 *a*, *c*, figs. 2, 4, 6), with other varieties of spines figured in this plate.

The test of this Urchin presents many variations of form from the typical shape seen in the specimen figured in Pl. XXIII, fig. 1 *a*, *b*, and considered to be its normal form. In Pl. XXIV, fig. 7, I have figured a remarkable monstrosity of this species from the British Museum Collection; it is inversely conical, like *Pseudodiadema lunidum*; measures three quarters of an inch in height, and is one inch and one third in diameter

above, contracting below down to the oral opening, which, at first sight, appears to be the summit of the test. In Pl. XXII, figs. 5 *a*, *b*, *c*, I have given drawings of a young test from the National Collection.

Affinities and Differences.—This species forms one of the most typical forms of the genus *Cyphosoma*, well characterised by its large size, round and inflated at the ambitus, highly ornamented at the base, and having the poriferous pores distinctly bigeminal in all the upper part of the zones; the secondary tubercles are large above the ambitus and small at the base; the spines are strong, elongated, and furnished with a striated collar, having the summit sometimes flattened and carinated, or expanded and spatulate, as seen in the different figures.

The nearest affinities of *C. Königi* are with *C. granulosum*, from which it differs in having large secondary tubercles above the ambitus and a more ornamented test at the base. In size and height, and in the disposition of its tubercles on the upper surface, as well as in the bigeminal arrangement of the pores in the upper part of the zones, it much resembles *C. magnificum*, Agass., from the Étage Sénonien inférieure of the south-west of France.

Locality and Stratigraphical Position.—*C. Königi* is found in fine preservation in the Upper Chalk of Kent, Sussex, Norfolk, Wiltshire, and Yorkshire. In France it is collected in the Étage Sénonian at Thuison (Somme); Tartigny (Oise); Vernonnet, La Villette, Hougouemarre (Eure); where it is rare. It is likewise found at Rügen, and Cæsfeld, near Dusseldorf.

Cyphosoma corollare, *Klein*. Pl. XXVI, figs. 7, 8, 9, 10.

Echinites orbiculatus,	*Lister*.	Hist. Animal. Angliæ, p. 220, pl. vii, fig. 19, 1678.
Cidaris corollaris,	*Klein*.	Natur. Dispos. Echinoderm., pl. viii, fig. c, p. 20, 1734.
— —	*Baier*.	Oryctographia Norica, p. 70, pl. iii, fig. 36, 1759.
— —	*Leske*.	Klein, Nat. Dispos. Echinoderm., p. 138, pl. viii, fig. c, 1778.
— coronalis,	*Gmelin*.	Linné's System. Natur., p. 3177, 1788.
Echinus saxatilis,	*Parkinson*.	Organic Remains, pl. iii, fig. 1, 1811.
Cidaris corollaris,	*Parkinson*.	Ibid., pl. i, fig. 7, 1811.
— saxatilis,	*Mantell*.	Geology of Sussex, p. 180, 1822.
— corollaris,	*Mantell*.	Ibid., p. 181, 1822.
Echinus saxatilis,	*Fleming*.	History of British Animals, p. 479, 1828.
— —	*Brongniart*.	Tableau des Terrains, p. 405, 1829.
— —	*Woodward*.	Synop. Table of Brit. Org. Remains, p. 6, 1830.
— —	*De Blainville*.	Zoophytes, Dict. des Sc. Nat., t. lx, p. 210, 1830.
Cidaris corollaris,	*Agassiz*.	Prodrome des Radiaires, p. 188, 1836.
Echinus corollaris,	*Desmoulins*.	Études sur les Échinides, p. 298, 1837.

CIDARIS COROLLARIS,	*Morris.* Catalogue of British Fossils, p. 49, 1843.
— SAXATILIS,	*Morris.* Ibid., p. 50, 1843.
CYPHOSOMA COROLLARE,	*Agassiz* et *Desor.* Catal. Rais. des Échinides, p. 351, 1846.
CIDARIS COROLLARIS,	*Bronn.* Index Palæontologicus, p. 298, 1848.
— SAXATILIS,	*Bronn.* Ibid., p. 300, 1848.
CYPHOSOMA COROLLARE,	*D'Orbigny.* Prodrome, t. ii, p. 273, Ét. 22, 1850.
— —	*Forbes.* In Dixon's Geol. of Sussex, p. 340, 1850.
— —	*Forbes.* In Morris's Catalogue of Brit. Foss., p. 75, 1850.
PHYMOSOMA —	*Desor.* Synop. des Échinides fossiles, p. 88, 1856.
CYPHOSOMA SAXATILE,	*Desor.* Ibid., p. 87, 1856.
— COROLLARE,	*Pictet.* Paléontologie, 2e éd., t. iii, p. 243, 1857.
— —	*Woodward.* Mem. Geol. Surv., Decade V, p. 2, 1858.
— —	*Leymerie* et *Raulin.* Géol. du Départ. de l'Yonne, p. 621, 1858.
PHYMOSOMA SAXATILE,	*Dujardin* et *Hupé.* Hist. des Echinoderm., p. 508, 1862.
— COROLLARE,	*Dujardin* et *Hupé.* Ibid.
CYPHOSOMA PERFECTUM,	*Cotteau* et *Triger.* Échinides de la Sarthe, p. 261, pl. xlii, figs. 13—16, 1860.
— —	*Cotteau.* Échinides foss. des Pyrénées, p. 24, 1863.
— COROLLARE,	*Cotteau.* Pal. Française, t. vii, p. 669, pl. 1165, 1864.

Test small, circular, depressed; ambulacra wide, two rows of tubercles, nine to ten in each, gradually diminishing in size towards the poles; inter-ambulacra moderate, with two rows of tubercles, nine in each, four ambital, large; areolæ defined by rows of granules; miliary zone moderate, granular below, becoming smooth above; poriferous zones narrow, undulated, pores unigeminal, and crowded near the summit; base concave; oral opening small, one third of an inch in diameter; discal opening large, pentagonal, half an inch in diameter; spines long, slender, spatulate, one fourth longer than the diameter of the test.

Dimensions.—Transverse diameter one inch; height one third of an inch; in general the specimens are not so large.

Description.—This is one of our most common *Cyphosomata*. In certain localities it is a small, circular Urchin, rarely exceeding an inch in diameter and about three or four lines in height; it is convex and depressed above, and flat or subconcave below; the areas are nearly equal in width, the tubercles very much alike in form and size, the areolæ are encircled with granules, and the structure of the different divisions of the test is very uniform throughout.

The ambulacral areas (Pl. XXVI, fig. 10), contracted above by the poriferous zones, have two rows of primary tubercles supported on large bosses, and arranged in alternate series on each side of the area; in adult specimens there are nine or ten tubercles in a row; the areolæ are wide, and a single row of granules (rarely double) separates them from each other.

The poriferous zones are narrow, and much undulated at the ambitus and infra-mar-

ginal region; the small pores are arranged in oblique pairs at the sides, and at the upper surface become bigeminal; fig. 10 shows an ambulacral area with its poriferous zones magnified six diameters; fig. 7 *b* exhibits the upper part of the area magnified six times, with the bigeminal arrangement of the pores in the upper part of the zones.

The inter-ambulacral areas are furnished with two rows of tubercles nearly identical with those of the ambulacral; they are, however, a little larger than the latter in the upper surface, and are surrounded by areolæ that are placed wider apart. The secondary tubercles are very small and unequal in size; they form a series near the zones, one mammillated tubercle rising in each plate from the midst of numerous granules. They are most apparent at the lower surface and the ambitus, and are rare on the upper surface.

The miliary zone is wide, naked, and depressed in the upper surface, forming at the ambitus and lower surface a zigzag line, which defines the contour of the plates. The granules are large, and those surrounding the primary tubercles at the ambitus send prolongations into the areolæ, which impart a radiated character to the structure of these parts. The intermediate granules are more or less abundant, and form circles or semicircles around the areolæ. The small mouth-opening is lodged in a concave depression in the base. The peristome is circular, and divided by feeble incisions, the lobes of which are nearly equal. The apical disc is absent. The opening is large, pentagonal, and angular, and in our large specimen is about five lines in diameter.

The spines are long, slender, and spatulate, one fourth longer than the diameter of the test, to which they are sometimes found adherent and *in sitú*.

Affinities and Differences.—*C. corollare* is readily recognised by its moderate size, depressed circular test, sometimes subpentagonal; the pores are unigeminal on the sides and bigeminal on the upper surface, with small secondary tubercles at the base near to the zones; the miliary zone is nude and depressed near the summit; the mouth-opening is small, and lodged in a concave depression. By these characters it may be distinguished from *C. tiara* and young examples of *C. granulosum*, both of which it resembles much.

Locality and Stratigraphical Position.—This Urchin is very common in the upper flinty Chalk of Brighton, Gravesend, and Woolwich. In France M. Cotteau enumerates the following localities in which it is rarely found in the Étage Sénonien:—Senneville, Saint-Pierre en Port (Craie supérieure, M. Hebert); Seine Inférieure, La Herelle (Oise); Pinterville (Eure); Villeneuve-sur-Yonne (Yonne); Meudon (Seine-et-Oise); Sarlat (Dordogne); Tercis (Landes).

History.—The history of this species, one of the oldest Cyphosomas, is very difficult to trace, as our table of synonyms has already exposed. Lister and Klein have both figured it, and Parkinson has given a very good figure of it under the name of *Echinites saxatilis* in his 'Organic Remains.' Klein's name, however, has the priority, and therefore is retained.

PLATE XXII.

Echinocyphus from the Grey Chalk.

Fig. 1 *a*. Echinocyphus difficilis, *Agassiz*. Test, natural size. British Museum. (P. 116.)

1 *b*. Ambulacral and inter-ambulacral plates, magnified four diameters, do. Do.

Fig. 2 *a*. Echinocyphus difficilis. Upper surface, magnified three diameters. The Rev. T. Wiltshire, F.G.S.

2 *b*. ,, ,, Under surface, do. do. Do.

2 *c*. ,, ,, Lateral view, do. do. Do.

2 *d*. ,, ,, Ambulacral and inter-ambulacral plates, magnified six times.

Fig. 3 *a*. Echinocyphus mespilia, *Woodward*, sp. Test, natural size. (P. 119.) British Museum.

3 *b*. ,, ,, Upper surface, magnified three diameters.

3 *c*. ,, ,, Under surface, do. do.

3 *d*. ,, ,, Lateral view, do. do.

3 *e*. ,, ,, Ambulacral and inter-ambulacral plates, magnified eight diameters.

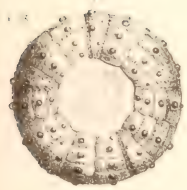
Fig. 4. Echinocyphus difficilis. Apical disc, magnified four times.

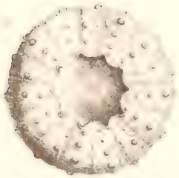
Fig. 5 *a*. Cyphosoma Königi, *Mantell*. Young test, natural size. British Museum. (P. 131.)

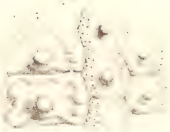
5 *b*. ,, ,, Under surface, do. Do.

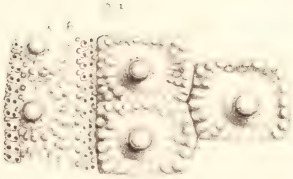
5 *c*. ,, ,, Lateral view, do. Do.

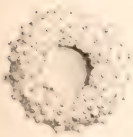
5 *d*. ,, ,, Upper third of ambulacrum, magnified four times.

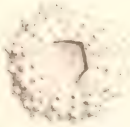












C R Bone del et lith.

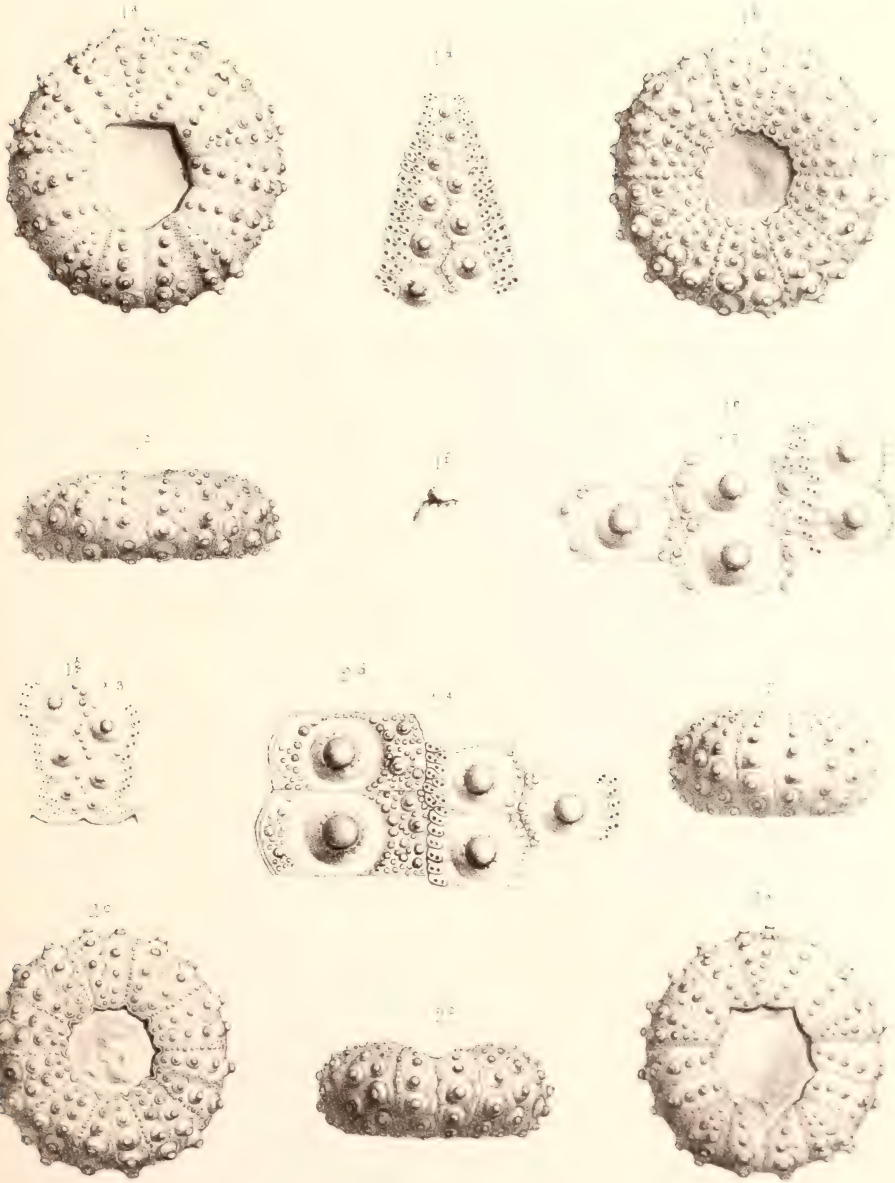
PLATE XXIII.

From the Upper White Chalk.

Fig. 1 *a*. Cyphosoma Königi, *Mantell*. Upper surface, natural size. (P. 131.)
1 *b*. „ „ Under surface, natural size. British Museum.
1 *c*. „ „ Lateral view, do.
1 *d*. „ „ Upper part of ambulacral area, magnified three times.
1 *e*. „ „ Portion of the areas and pores, magnified three times.
1 *f*. „ „ Boss and mammillon, highly magnified.
1 *g*. „ „ Inferior portion of an ambulacrum, magnified three times.

Fig. 2 *a*. Cyphosoma granulosum, *Goldfuss*. Upper surface, natural size. (P. 129.)
2 *b*. „ „ Under surface, natural size. British Museum.
2 *c*. „ „ Lateral view, showing the depression of the upper surface.
2 *d*. „ „ Portion of the areas and pores, magnified four times.

Fig. 3. Cyphosoma Königi, *Mantell*. Elevated variety. British Museum.



C.R.Bone del et lith

PLATE XXIV.

From the Upper White Chalk.

Fig. 1 *a*. Cyphosoma Königi, *Mantell*. A fine specimen, with the spines *in situ*, natural size. British Museum. (P. 131.)

1 *b*. ,, ,, Ramiform spine, natural size.

1 *c*. ,, ,, do., do., magnified three times.

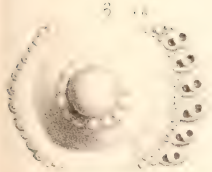
1 *d*. ,, ,, Bent spine, magnified twice.

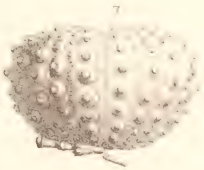
Fig. 2. ,, ,, Test, with spines. Rev. T. Wiltshire, F.G.S. Natural size.

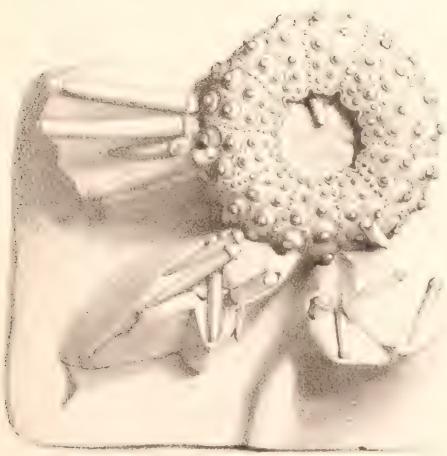
3 *a*. ,, ,, Bent spine
3 *b*. ,, ,, do., magnified six times
4. ,, ,, Spatulate, do.
} British Museum.

6. ,, ,, Inter-ambulacral plate, magnified six times.

7. ,, ,, Elevated variety. British Museum.





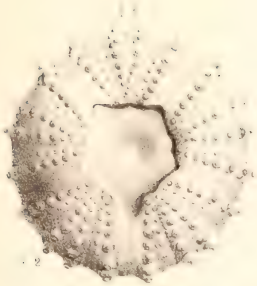


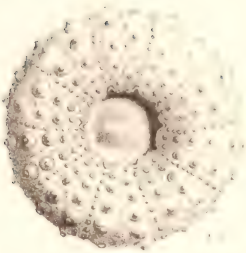
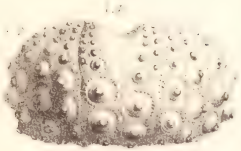
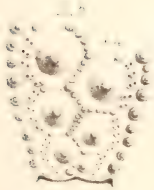
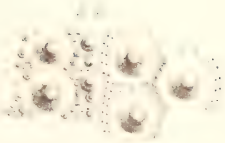
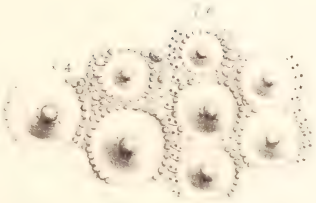
Bone. del. et lith.

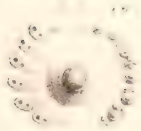
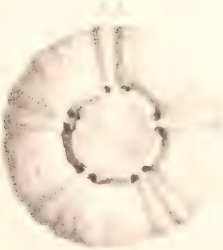
PLATE XXV.

Cyphosomas from the Upper White Chalk.

Fig. 1 *a*. Cyphosoma magnificum, *Agassiz*. Natural size. Rev. T. Wiltshire. (P. 137.)
1 *b*. ,, ,, Upper surface, magnified twice. Do.
1 *c*. ,, ,, Under surface, do. Do.
1 *d*. ,, ,, Lateral view, do. Do.
Fig. 2 *a* ,, ,, Upper part of areas, magnified four diameters.
2 *b*. ,, ,, Base of ambulacrum, do. do.
2 *c* ,, ,, Tubercle, magnified six diameters.
Fig. 3 *a*. Cyphosoma Königi, *Mantell*. Mould in flint. Upper surface. (P. 131.)
3 *b*. ,, ,, Do. Under do.



G.R.Bone del. et lith.

PLATE XXVI.

Cyphosomas from the Upper White Chalk.

Fig. 1 *a, b, c.* Cyphosoma Königi. Spoon-shaped spines, magnified. The Rev. T. Wiltshire, F.G.S.

2. „ „ Club-shaped spine, do. Do.

3 *a, b.* „ „ Awl-shaped spine, magnified six times. Do.

4, 5, 6. „ „ Conical and spoon-shaped, do. Do.

Fig. 7 *a.* Cyphosoma corollare, *Klein.* Test, natural size. British Museum. (P. 134.)

7 *b.* „ „ Upper third of an ambulacrum, magnified six times.

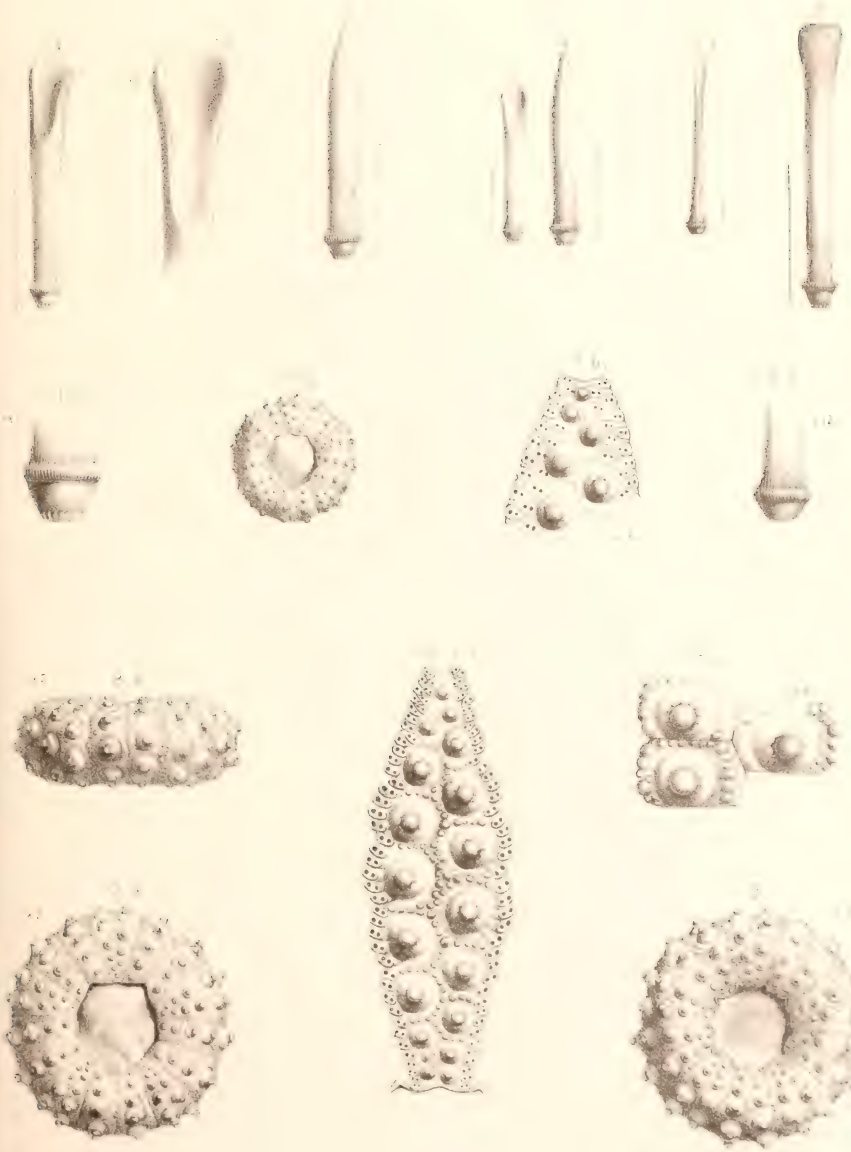
7 *c.* „ „ Inter-ambulacral plates, do. do.

8 *a.* „ „ Upper surface of another test, magnified twice, do.

8 *b.* „ „ Lateral view of do., do., do.

9. „ „ Under surface of do., do., do.

10. „ „ Ambulacral area, magnified six times. The Rev. T. Wiltshire, F.G.S.



C R Bone del et lith.

PLATE XXVII.

From the Upper White Chalk.

Fig. 1 *a*. Cyphosoma Wetherelli, *Forbes*. Test, natural size. Museum of the Royal School of Mines. (P. 139.)

1 *b*. ,, ,, The upper surface of do., magnified twice.

1 *c*. ,, ,, The under surface of do., do.

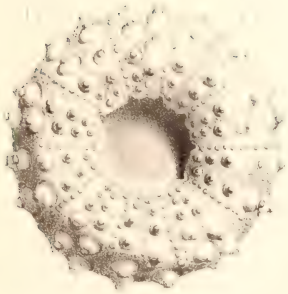
1 *d*. ,, ,, The lateral view of do., do.

1 *e*. ,, ,, Areal plates and zones, magnified six times.

1 *f*. ,, ,, Lateral view of a single tubercle, magnified.

1 *g*. ,, ,, Upper portion of an ambulacrum, magnified six times.

1 *h*. ,, ,, Inferior portion of do., do.



C R Bone, del et lith

PLATE XXVIII.

From the Upper White Chalk.

Fig. 1 *a*. CYPHOSOMA SPATULIFERUM, *Forbes*. Test, natural size. British Museum. (P. 141.)

1 *b*. ,, ,, Upper surface of do., magnified twice.

1 *c*. ,, ,, Under surface of do., do. do.

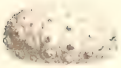
1 *d*. ,, ,, Lateral view of do., do. do.

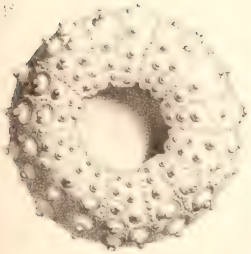
1 *e*. ,, ,, Inter-ambulacral plates, do. six times.

1 *f*. ,, ,, Ambulacrum entire, do. do.

1 *g*. ,, ,, Inter-ambulacral plates, do. do.

1 *h*. ,, ,, Lower portion of an ambulacrum, magnified six times.





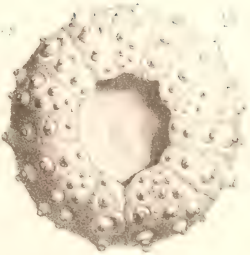


PLATE XXIX.

From the Upper and Lower Chalk.

Fig. 1 *a*. CYPHOSOMA SPATULIFERUM, var. The Rev. T. Wiltshire, F.G.S. (P. 141.)

1 *b*. „ „ Upper surface of do., magnified twice.

1 *c*. „ „ Lateral view of do., do. do.

1 *d*. „ „ Areal plates and zones, do. six times.

2 *a*. CYPHOSOMA SIMPLEX, *Forbes*. Royal School of Mines. (P. 143.)

2 *b*. „ „ Upper surface of test, magnified two and a half times.

2 *c*. „ „ Upper portion of ambulacra, do. six times.

3 *a*. „ „ Another test, magnified three times.

3 *b*. „ „ Radiated areolæ, magnified eight times, Museum of the Royal School of Mines.

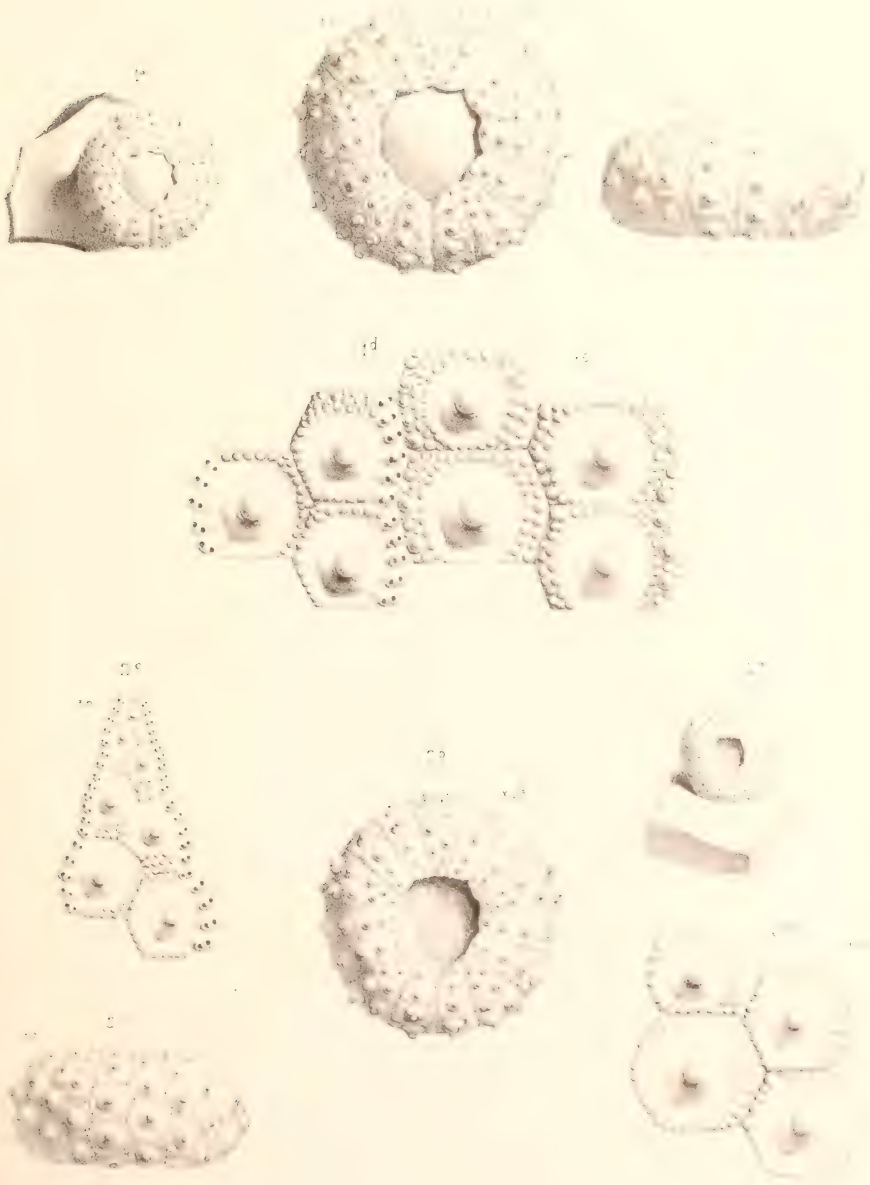


PLATE XXIX A.

From the Chloritic Marl.

Fig. 1 *a*. Pedinopsis Wiesti, *Wright*. Test, natural size, upper. From the Collection of W. Wiest. (P. 114.)

1 *b*. ,, ,, Under surface of do., natural size.

1 *c*. ,, ,, Lateral view of do., do.

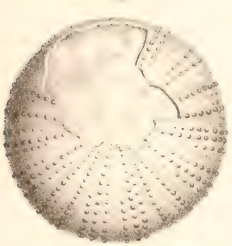
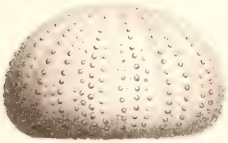
1 *d*. ,, ,, Upper third of an ambulacrum, magnified six times.

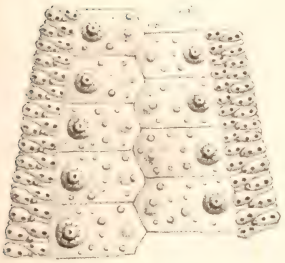
1 *e*. ,, ,, Inter-ambulacrum plates, do., do.

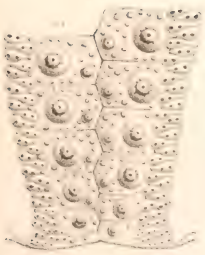
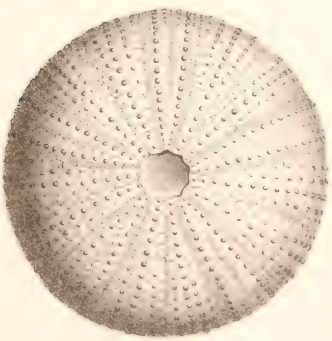
1 *f*. ,, ,, Do. do., do., do.

1 *g*. ,, ,, Areal plates and zones, do., do.

2. Pedinopsis Meridanensis, *Cotteau*. Copied from Pl. 1125, fig. 2, of the 'Paléontologie Française,' for comparison with *P. Wiesti*.



C R Bone del et lith

PLATE XXIX B.

From the Upper and Lower Chalk.

Fig. 1 *a*. GLYPHOCYPHUS RADIATUS, *Hœninghaus*, sp. Test, upper surface, magnified twice. (P. 121.)

1 *b*. ,, ,, Lateral view, magnified twice.

1 *c*. ,, ,, Areal plates and zones, do. ten times.

Fig. 2 *a*. ,, ,, Under surface, do. twice.

2 *b*. ,, ,, Apical disc (from M. Cotteau's figure), magnified.

2 *c*. ,, ,, Areal plates and zones (do. do.) do.

2 *d*. ,, ,, Inter-ambulacrum (do. do.) do.

2 *e*. ,, ,, Ambulacrum (do. do.) do.

Fig. 3 *a*. ECHINOTHURIA FLORIS, *Woodward*. Portion of test, natural size, in the British Museum. (P. 125).

3 *b*. ,, ,, Poriferous zones, magnified four times, do.

Fig. 4 *a*. ,, ,, Do. do., do. do.

4 *b*. ,, ,, Portion of spine, do. six times.

4 *c*. ,, ,, Do. do., do. do.

4 *d*. ,, ,, Areal plates, do. four times.

5 *a*. ,, ,, Ovarial plates, natural size.

5 *b* ,, ,, Jaws, forming "the Lantern of Aristotle," natural size.

C.B.Bone del. et lith.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1869.

LONDON:
MDCCCLXX.

A MONOGRAPH

OF

BRITISH BELEMNITIDÆ.

BY

JOHN PHILLIPS,

M.A. OXON., LL.D. DUBLIN, LL.D. CAMBRIDGE, D.C.L. OXON., F.R.S., F.G.S., ETC.,
PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF OXFORD.

PART V,

CONTAINING

PAGES 109—128; PLATES XXVIII—XXXVI.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1870.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

BELEMNITES OF THE OXFORD CLAY.

In passing upward from the thin-bedded rocks of Stonesfield, we find few or no Belemnites for a considerable thickness of the Oolites. Through the whole series of the Great Oolite, Bradford Clay, Forest Marble, and Cornbrash, Belemnites, if ever found, are very rarely seen in the South of England. In the North of England, the doubtful "Grey Limestone," as I termed it, of the Yorkshire Coast, contains Belemnites, but they are of the type of Inferior Oolite, and with *Ammonites Blagdeni*, *Am. Humphreysianus*, and *Am. Parkinsoni*, must be held to carry that rock to the "Lower Badonian" stage. Is the Great Oolite of the South of England wholly devoid of Belemnites, except in its lowest member, the Stonesfield slate? I can only reply that no specimen has occurred to my personal observation. Does the Bradford Clay contain any Belemnites? Only one notice is on record, and that is in the now rarely seen volume, published by W. Smith, under the title of 'Stratigraphical System of Organized Fossils,' 1817. In that work, page 79, occur these words:—"Multilocular bivalves. Belemnites small, slender; Stoford." As my boyish hand wrote the words—the place being familiar to me, I have no reason to doubt the accuracy of the record. The specimen was transferred to the British Museum. No Belemnite is mentioned in the Forest Marble beds, nor, so far as I now remember, has any one been quoted from the Cornbrash, except by error. In the first edition of my work on the 'Geology of the Yorkshire Coast,' 1829, I remarked (p. 145) "No Belemnites have been found in the Cornbrash of Yorkshire;" and again (p. 146), "The Cornbrash is the only conchiferous stratum in the eastern parts of Yorkshire from which Belemnites are excluded." In consequence of some notice reaching me of a specimen found in the Cornbrash of Yorkshire between 1829 and 1835, I modified the expression in the Second Edition, so as to call attention to the extreme rarity of the occurrence. If any Palæontologist whom these remarks may reach should find himself able to furnish me with specimens of Belemnites from beds between the Cornbrash and Stonesfield slate, of any part of England, he would oblige me much by a sight of them.

There being then, as appears, this great blank in regard to Belemnites (the remark is almost equally good for Ammonites, but in this case we must exclude the Cornbrash), through a considerable range of conchiferous strata, it becomes a matter of great interest to compare the several Oxonian forms which now appear, with the numerous Badonian species which have disappeared. Are these the same species matured in some other part of the sea, modified there through a long succession of transmitted forms, and again brought into the Oolitiferous ocean? We may consider this question after the facts have been collected and studied.

Among the Belemnites of the Oxford Clay and the Kelloway Rock (a sandy member

which is not seldom absent from the section), four principal forms appear to have reached maturity in the area of England, which may, for convenience, be termed '*Hastati*,' including *B. hastatus* of Blainville; '*Canaliculati*,' including *B. sulcatus* of Miller; '*Tornatiles*,' including *B. Puzosianus* of D'Orbigny; and '*Excentrici*,' including *B. abbreviatus* of Miller. When we endeavour to trace the history of these several forms, from the youngest examples, we experience in more than the usual degree the difficulty of obtaining a series of all ages for any one of the species.

However carefully we may collect, in many favourable localities, it is nearly impracticable to fill up all the terms of the series; and though scores of young ones have been collected by my own hands from different localities, it is only in a few instances, and by the aid of my pupils, that I have succeeded in proving to my own satisfaction the real progress of these several forms towards maturity. Nor does the method of examination by sections of the older individual succeed in this case so well as in some others, because of the frequently very close texture of the sparry substance, and its more complete condensation into an amber-coloured mass, than is usual in the earlier deposits. For this reason the form of the very young shell cannot always be even approximately known by examining polished or natural sections. As far as can be judged from these sections, however, there is reason to think that most of the Belemnites of the Oxford Clay began life in a more or less hastate, or else lanceolate, shape; and this seems to be confirmed by the fact, as I believe it to be, that no very small specimen has ever been observed in the Oxford Clay or Kelloway Rock in England, except in one of these shapes. Extending our view to Scotland, we find a somewhat different result. The Belemnites of the Cromartie coast have been collected very successfully at Eathie and Shandwick by Lieut. Patterson, of Ripon, to whom I am obliged for the sight of his fine series, and for photographs of many specimens.

Two species at least have there arrived at maturity; one, a peculiar elongated spicular Belemnite, whose guard sometimes reaches the length of ten inches, is found in Mr. Patterson's series of all sizes down to one inch: it is only in this very small and very slender specimen that any approach to a fusiform shape of the guard can be recognised, and then only in a very slight degree. Another of these species makes an approach to *B. sulcatus* of Miller, and is longitudinally grooved up to the point, at least in all the smaller specimens (Shandwick).[1] There is nothing in the smallest of these at all comparable to the clavate forms common in the Oxford Clay of England, though a slightly hastate shape can be recognised among them. The strata from which these Belemnites come have been called Lias, but what *Ammonites* and *Conchifera* I have seen from them are of the Oxonian type of life.

Two of the four Oxonian groups have been already mentioned in the Badonian

[1] In Lieut. Patterson's Collection is one specimen of a decidedly Liassic Belemnite of the group of *B. elongatus* (Miller), which is placed among the Shandwick fossils.

Oolites (*Hastati* and *Canaliculati*); the others (*Tornatiles* and *Excentrici*) now first make their appearance, to replace (perhaps we may say) the *Gigantei*, which they, however, resemble in no particular except size.

BELEMNITES HASTATUS, *Blainville*. Pl. XXVIII, figs. 67—70.

Reference. Var. *a*. *Belemnites hastatus*, Blainville, 'Mém. sur les Bélemn.,' p. 71, pl. 2, fig. 4, 4*a*. 1827.
Belemnites semihastatus, Blainv., 'Mém. sur les Bélemn.,' p. 72, pl. ii, fig. 5, 5*a*—5*g*. 1827.
Belemnites gracilis, Phillips, 'Geol. of Yorkshire,' vol. i, p. 138, pl. v, fig. 15. 1829.
Belemnites hastatus, D'Orb., 'Terr. Jurass.,' p. 121, pl. xviii, fig. 1, 9. 1842. (Exclude some of the synonyms.)
Belemnites hastatus, Quenstedt, 'Cephalopoda,' p. 442, pl. xxix, fig. 27—39. 1849.
Belemnites semihastatus rotundus, Quenstedt, 'Cephal.,' p. 440, pl. xxix, fig. 8—11. 1849.
Belemnites semihastatus depressus, Quenstedt, 'Cephal.,' p. 440, pl. xxix, fig. 12—18. 1849.

GUARD. Very elongate, smooth, hastate, with an acute apex (by decay of laminæ about the alveolar apex it becomes fusiform); in all stages of life depressed and expanded laterally in the post-alveolar region; cylindrical or somewhat compressed about the alveolus; ventral surface marked by a distinct groove, which is extended forward over the alveolar cavity, and backwards toward the apex, about half the length of the axis of the guard, so as to leave much of the expanded part free from groove, or with merely a faint indication or trace of groove. In young specimens this part appears swollen on the ventral aspect (see fig. 69, 2^2, 2^4).

Transverse sections show the laminæ of the guard thickening on the dorsal aspect of the alveolar cavity, so as to make the section circular, or a little oblong there; the sectional outline is depressed and reniform in the post-alveolar region, till the bulbous part is reached, which has an oval section gradually growing circular toward the conical or slightly submucronate point. The axis is nearly central. In some excellent specimens are small faint longitudinal bent or sigmoidal furrows one on each side of the guard. They begin nearer to the ventral than the dorsal surface, and bend upward before losing their distinctness (figs. 68*l*, 67*l*).

Dimensions. In the Oxford district within a few miles of the city, the clay-pits have been well searched for these Belemnites, and with great success as far as the young

forms are concerned. Only one specimen has yet been met with corresponding in size to the figures of D'Orbigny and Quenstedt already referred to. This is in the collection of Mr. James Parker, from the Cowley clay pit at its deepest part, about 80 feet below the Calcareous Grit. This specimen has a total length of 6·75 inches; greatest breadth 0·65; least 0·40; greatest depth 0·60; least 0·40; axis = 5·5 inches. Between this fine and solitary specimen and very many examples 2¼ inches long, no intermediate magnitudes have yet, near Oxford, been found; the smallest specimens, like oat grains, are about half an inch long, and then by decay of the laminæ about the alveolar apex acquire the aspect of the so-called 'Actinocamax' of Miller.

Proportions. In young specimens the axis is about seven times as long as the greatest post-alveolar breadth, and about ten times as long as the breadth at the alveolar apex: in an old specimen, the axis is fourteen times as long as the alveolar breadth, and nine times as long as the greatest post-alveolar breadth.

It was with great pleasure that I received from the Oxford Clay of Eyebury, near Northamptonshire, a specimen found by Mr. Leeds (Pl. XXVIII, fig. 68), which happily fills up the blank in the history of the species, by a form of intermediate magnitude, not elsewhere recognised. We are thus assured of the persistence of the hastate form in this species through all stages of growth yet observed, from the very young to the apparently full-grown individuals.

Phragmocone. Very few indications of this part of the fossil have been as yet seen by me. D'Orbigny, who had fine specimens at his disposal, figures the phragmocone of one ('Terr. Jurassiques,' pl. viii, fig. 1) in the sheath, and represents it as having an angle of about 15° (in the description it is said to be 11° to 18°), with chambers whose diameter is only four times their depth. Quenstedt ('Cephal.,' pl. 29, fig. 8 *a*, 9) presents the phragmocone of *B. semihastatus rotundus* (regarded as a variety of *B. hastatus* by D'Orbigny), with septal intervals equal to one fifth of the diameter, and an angle of 13°. These may be regarded as good characters for discriminating between this specific group and that of *B. ari-pistillum* of Stonesfield. The septa are more nearly round than in the figure of D'Orbigny.

Localities. In Oxford Clay, Weymouth; in the middle part of the clay north of the town; on the shore in the upper part of the clay; and south of the town. Oxford, in the lower or middle part of the clay, with *Ammonites Duncani*, at Summertown, one mile to the north; in the upper part of the clay at Cowley Field, half a mile to the south-east; and at Long Marston, in the upper part of the clay, one mile to the north-east (*Phillips*). Eyebury, near Peterborough, in the lower part of the clay (*Leeds*). St. Ives (*Walker*). Scarborough Castle Hill (*Phillips*). In Calcareous Grit, Scarborough (*Bean*).

Observations. D'Orbigny collects under one title the two fossils to which Blainville assigned the names of *Belemnites hastatus* and *B. semihastatus*. The differences between them were far from clear in the earlier author's descriptions or figures. Quenstedt

retains the distinct names, and is, in this respect, in agreement with other German writers. Collections in Germany follow this model in their arrangements. D'Orbigny joins to these *Belemnites fusiformis* of several writers, *B. ferrugineus* of Voltz, and *B. gracilis* of Raspail.

In considering the varieties to which the species seems liable, we find among English specimens, of lengths from half an inch to three inches, some differences in the general shape of the guard, which in some specimens is elegantly hastate (fig. 69, v^5), in others more expanded and recurved at the apex (fig. 69, l^2, v^3), in a few bulbiform (fig. 69, v^6, v^7), in one deformed (fig. 70, μ). The ventral groove is generally absent from half of the length of the axis of the guard; in rare cases (fig. 69, v^5) it is interrupted, sometimes it leaves more than half of the length of the axis of the guard smooth. I do not observe lateral furrows on any of the small specimens, and it seems rarely absent from any of the larger ones. In the older form, which exceeds six inches in length, the undulated, or somewhat oblique faint double furrow, is traceable nearly as D'Orbigny has represented it ('Terr. Jur.,' pl. xviii, fig. 4).

BELEMNITES HASTATUS, var. BULBOSUS. Pl. XXVIII, fig. 69, v^6, v^7.

The variety to which attention is now called, is more than any other remarkable for the retral expansion of the guard and the swollen ventral outline of the expanded part. In eleven specimens before me, including individuals from ¾ inch to 2½, the characters were nearly uniform. The broad part of the guard is about ⅓rd of the axis from the apex; the groove usually terminates at half the length of the axis from the apex; but in one specimen (fig. 69, v^7) it is interrupted and farther extended.

The sections are nearly round in and for a small space behind the alveolar portion, but everywhere further back they are elliptical. The laminæ over and a little behind the alveolar space are, as usual, pale and less calcareous than in the more solid part of the guard.

Locality. Specimens of this very interesting form have been forwarded to me by Mr. J. F. Walker, of Sidney Sussex College, Cambridge, from the Oxford Clay of St. Ives, Cambridgeshire, where they are accompanied by *B. Puzosianus* of D'Orbigny, and *B. sulcatus* of Miller.

I have examined in foreign collections a considerable number of specimens called *B. hastatus* and *B. semihastatus*, and considered the figures which are given as representing them. I am unable to perceive differences among them or among the comparatively few English examples of full size, such as to require the employment of more than one specific name. At the same time there are differences; some have a nearly circular section across the expanded part of the guard, others a depressed contour there; similar variations occur in the alveolar region. To the former the 'variety-name' of *rotundus* has been assigned, to the latter *depressus*. The somewhat flexuous lateral groove is absent in some and present in other examples not otherwise differing.

On a group of Belemnites, including *B. canaliculatus*, Schlotheim (in part); *B. sulcatus*, Miller (in part); *B. Altdorfensis*, Blainville *B. absolutus*, Fischer; *B. Beaumontianus*, D'Orbigny.

The canaliculated Belemnites above referred to are frequent in the Oxford Clay, and specially toward the lower part of it, as it occurs in England. They are found in the vicinity of Oxford, associated with *Ammonites Duncani*, in the parallel of the Kelloway Rock, or nearly so, for that rock is hardly traceable in this quarter. In the corresponding clay of Weymouth, Belemnites are found of the same general character, while at St. Neot's specimens occur which cannot in the least particular be distinguished from Oxford specimens.

Miller, while examining the Oxford Collection, certainly referred the channelled Belemnite of the neighbourhood to *B. sulcatus;* but a frequent application of this name is to a species of the Lower Oolite, such as *B. apiciconus*. We find in Schlotheim *B. canaliculatus* corresponding to *B. sulcatus* of Miller, and, like it, including forms from the Inferior Oolite and the Oxford Clay. Blainville rightly separates them, and assigns to his *B. Altdorfensis* one of Miller's figures (pl. viii, fig. 5, 'Geol. Trans.,' 2nd series, vol. ii), and a part of *B. canaliculatus* of Schlotheim. Quenstedt employs the general title of *B. canaliculatus* for all these forms, and includes in it the Stonesfield fossils referred to *B. Bessinus* by Morris and Lycett.

Belemnites having the same general character occur in the Oolitic series of Russia, with Ammonites of the Oxford Clay; and similar forms have come to my hand from the Himalaya.

Among all these fossils there is so much of resemblance that in the sense of the term species, as it was employed by the earlier naturalists who thought with Linnæus, they might be classified under one title, such as *B. canaliculatus*, the earliest on record, as Quenstedt does. But this title is equally claimed for the grooved Belemnites of the Bath Oolite series, which contain several very distinguishable and characteristic forms.

B. Altdorfensis of Blainville is supposed by this author to be identical with *B. canaliculatus* of Schlotheim and *B. sulcatus* of Miller, and is quoted from the ferruginous Oolite of Curey, near Caen.

D'Orbigny disposes of the perplexity of this nomenclature by instituting a new species, *B. Beaumontianus*, which he refers to the Lower Oxford Clay of Vaches-Noires. A fossil, corresponding to his figure, occurs at Loch Staffin in the Isle of Skye, according to Prof. E. Forbes. No other locality is given by Morris.

Upon the whole I am disposed to preserve the name which Miller certainly imposed on the long-grooved fossils from the Oxford Clay; the more so as it will be seen that hardly any examples fit so exactly with the figure of *B. Beaumontianus* given by D'Orbigny as to render that a good general type of a variable species.

Few Belemnites appear to have had so large a distribution in time and space as the group allied to *B. sulcatus* of Miller and *B. canaliculatus* of Schlotheim. From the base of the Inferior Oolite to the middle of the Oxford Clay they are generally recognised in Europe; specimens much like our examples from Oxford Clay are abundant in the country south of Moscow; others come to us from the Himalaya[1], from Cutch[2], South Africa[3], New Zealand,[4] and Queensland.[5]

BELEMNITES SULCATUS, *Miller*. Pl. XXIX, XXX; figs. 71—75.

Reference. *Belemnites sulcatus*, Miller, 'Geol. Trans.,' 2nd series, vol. ii, p. 59, pl. viii, fig. 5 [excl. fig. 3 and 4]. 1823.
Belemnites Beaumontianus, D'Orb., 'Pal. Franç., Terr. Jur.,' p. 118, pl. xvi, fig. 7, 11 (on the plate it is called *B. Altdorfensis*). 1842.

GUARD. Subcylindrical or conical in the alveolar region, more or less depressed in the post-alveolar region and deeply grooved; the groove interrupted or expanded toward the apex, and gradually ceasing about the alveolar summit. Outline nearly straight on the ventral, more curved on the dorsal aspect; apicial region tapering, surface smooth or granulated. Sections show the axis to be nearest the ventral face, very excentric, and somewhat recurved. Near the apex the sections are almost circular or a little oblong.

Greatest length observed 5·5 inches; and of this the axis occupied 3 inches. Greatest diameter in this specimen 0·85, in a stouter specimen 1·05.

Young. The very young form was more or less hastate (fig. 73 *v*[1]). Somewhat advanced in age is the very rarely seen form fig. 73 *v*, from near Oxford; next we have fig. 72 and 71 *v*, differing from full-grown specimens only in greater slenderness.

Proportions. The normal diameter (not counting the groove) being taken at 100, the transverse diameter of the alveolar apex is, in full grown individuals, 108; the axis under 300; the ventral radius 40; the dorsal 60. In young specimens the axis is 500.

PHRAGMOCONE. Slightly arched, very obliquely inserted; septa nearly circular, unusually approximate, their depth being about one eighth or even only one ninth of the diameter in the anterior part; sphericle distinct and rather large; angle 22°. The concave surface, within the septal edge, is a portion of a sphere, measuring 90° across.

Observations. There is some variety in the sections of the guard; some specimens showing more depression than others; in some the groove is broader, in others it is deeper; in a few the groove expands a little toward the apex (fig. 74 *v*), and also expands on the surface over the alveolus (fig. 75 *v'*); in some there are one or two lines parallel to the edges

[1] Specimen in my possession.
[2] Sowerby, 'Geol. Trans.,' 2nd Ser., vol. v, p. 329.
[3] Tate, in 'Geol. Soc. Journal,' 1867, p. 151.
[4] Hochstetter, Novara-Expedition.
[5] Specimens in the Collection of Mr. Charles Moore.

of the groove (fig. 75 *v'* and *v''*). There is often a marked increase of depth and definition of the groove for half the length of the guard, measuring back from the alveolar region, as if in that part was a fissure (fig. 71, *v'*, *v*). A faint intimation of the groove can almost always be traced to near the apex.

Specimens occur with an external sheath of white fibrous matter, rough on the outer surface (Pl. XXIX, fig. 72 *m*). One might fancy this to be a periostracon or capsule, but it is, I believe, really a concretionary deposit. The shell is sometimes granulated (Pl. XXIX, fig. 72 *m*).

In figure 10, pl. xvi, of the 'Pal. Franç.' the outline of the alveolar cavity, erroneously represented as somewhat transverse, should have been very nearly circular. The Oxford specimens are never so much depressed in the post-alveolar region as in fig. 9 of the same plate.

The axis of the guard of this Belemnite, in some specimens obtained from the Oxford district, is hollow for a part of the length, as if the apices of the young laminæ of the guard were, during life, removed, so that a sort of pipe, partially interrupted at intervals by the edges of these laminæ, extended inwards from the perforated apex. Afterwards the sheaths successively formed covered them completely, and were not perforated. In some specimens (fig. 71 s', A', A'') the axial canal is very narrow for a certain space above the alveolar cavity, then it enlarges in a fusiform shape, and again contracts to the mere line of junction of the opposite guard-fibres. This curious appearance will be further considered in connection with *B. abbreviatus*.

Another very curious fact is observed in several of these fossils. On the ventral aspect, internally, are one or two cavities extended lengthways, through the substance of the guard, from a little in front of the alveolar apex to a greater distance behind. An explanation is found by the aid of cross sections: for these, taken a little behind the alveolar apex, show the cavities in question to be formed by the peculiar inflexion of the laminæ of the guard on the ventral aspect. This inflexion becomes remarkable only after a certain age; thenceforward grows continually deeper and deeper, always producing a groove, and sometimes by the contraction of this groove completely or partially enclosing longitudinal canals.

Fig. 71 *s* shows the arrangement of the laminæ round the axis of the guard in conformity with this description. The axis is not tubular in this instance. The laminæ of the guard are crossed by the fibres nearly at right angles to the surface, and as this is a curve of contrary flexure about the ventral aspect, the fibres assume there remarkably arched directions. In these sections glistening dagger-shaped parts are present—they are merely the obliquely truncated prismatic cells of the so-called fibrous structure. It may be well to mention, that the specific gravity of most Belemnites (2·8) agrees with that carbonate of lime called arragonite, and not with ordinary calcite.

The student of Homology will not fail to remark the analogy which this repetition of deep folds on the ventral aspect of *Belemnites sulcatus* offers to the more regular groove on the same aspect in *Belemnitella*. The groove of the latter group, however, is only on

the alveolar region, and reaches to its anterior edge, which is emarginate in consequence, while that of *B. sulcatus* belongs to the posterior part, dies out on the same region, and ceases nearly opposite the alveolar apex. The canaliculated axis occurs in some examples of *B. Bessinus* of Stonesfield and in *B. lateralis* of Speeton, but I have not yet seen it in any Liassic species.

Belemnites perforatus, Voltz (Pl. VIII, fig. 2), from Cretaceous beds at Osterfeld, is canaliculated for the whole length of the axis of the guard; and specimens of *B. quadratus* and *B. mucronatus* from the Chalk frequently show this peculiarity, or else a condition of the central parts which suggests their easily acquiring it.

Locality and distribution. Weymouth has yielded characteristic specimens of this species from the Oxford Clay, but they seem not to be plentiful there. I found only two or three fragments in the clay on the shore north of Weymouth, mixed with hundreds of the young forms of a hastate Belemnite. It is not mentioned among the fossils of the Oxford series known to Smith, who figures and describes the longer Belemnite known at Chippenham as *B. Owenii*. About Oxford we find it rather frequently, especially towards the middle and lower part of the clay deposit, with *Ammonites Duncani*, while in the upper part *B. Owenii* and *B. eccentricus* occur more frequently, with *Ammonites cordatus*. The young forms are very rare in these parts. Near St. Neot's, again, they occur with *Ammonites Duncani*, but not plentifully, as I find by Mr Walker's communications, and again near Peterborough, as I learn from Mr. Leeds. I doubt the occurrence of the species in Yorkshire, and regard the mention of it in the first edition of my work on the geology of that county (1829) as requiring confirmation.

The locality of D'Orbigny's fossil is thus noticed:—"Elle a été recueillée par M. Tesson dans les marnes Oxfordiennes des Vaches-Noires (Calvados); elle parait y être rare."

On a Group of Belemnites allied to *Belemnites Puzosianus* of D'Orbigny.

In 1816 William Smith figured, in his 'Strata Identified,' on the plate of Oxford [Clunch] Clay fossils, a long subcylindrical Belemnite from Dudgrove Farm, in Wilts. In his 'Stratigraphical System' (1817) the fossil is described as "large, squarish, quickly tapering to the apex; diameter one inch at the largest end, length four or five inches. The figure referred to represents the guard almost complete, with the alveolar cavity exposed. I remember the specimen, which is now in the British Museum. Some years later the species was recognised by my great relative in a fossil of the Kelloway Rock in Yorkshire, to which I gave the name of *B. tornatilis*. Of this I had seen specimens when the first edition of my work on the 'Geology of Yorkshire' was published (1829), and described the fossil as elongated. In the second edition it was named, with an equally brief description, but no figure (1835). In 1844 the rich deposit of

Chippenham had yielded its treasures, and Belemnites of the same general aspect, with considerable portions of the phragmocone, and even extensions of the conotheca, had furnished to Prof. Owen the materials for a valuable essay on the structure of the shell and the relations of the animal ('Phil. Trans.,' 1844). The fossil was named by Mr. Pratt *B. Owenii*.

The same great record of science contains, in the volume for 1848, another "Essay on the Belemnites of Chippenham," by Dr. Mantell, in which the figures represent a variety of important facts previously unobserved. The Belemnite which he examined is here called *B. attenuatus*—a name long before appropriated to a species found in the Gault, which had, however, been referred to a new genus, *Belemnitella*. D'Orbigny makes known to us a very similar form of Belemnite, also from the Oxford Clay, to which he gives the name of *B. Puzosianus*. Finally, Mr. Morris, in his excellent 'Catalogue of British Fossils,' 1854, employs the term *B. Owenii*, giving *B. Puzosianus* as a synonym, and under *B. tornatilis* proposes the question if it be not identical with *B. Owenii*.

The natural group thus noticed consists of Belemnitic guards of more than the usual length, with a generally cylindrical aspect, more or less compressed; always marked by a depression, often by a conspicuous groove, from the apex along the ventral surface for a third or half the length of the axis.

To the forms best known must be added one or two more from the midland district of England, and as many from the Oolitic series of the coast of Cromarty. These are inordinately long, but in other respects correspond in general character with the more usual species.

Looking back upon earlier groups of Belemnites, we find nothing so much like these as the long, somewhat compressed forms allied to *B. tripartitus* (see Pl. XI, fig. 28), in the Upper Lias. But all those Liassic forms have lateral grooves near the apex, often very conspicuous; these of later ages, in the Oxonian strata, never.

In regard to the synonymy, there can be little doubt about preserving Mr. Pratt's name, *B. Owenii*, for the whole group; *B. Puzosianus*, D'Orbigny, having certainly to be associated with it, as a variety.

Belemnites Owenii, *Pratt*. Pls. XXXI, XXXII, figs. 76—81.

Reference. *Belemnites* (unnamed), Smith, 'Strata Identified,' 1816, and 'Stratigraphical System,' p. 55, 1817.
B. tornatilis, Phillips, 'Geol. of Yorkshire,' vol. i, ed. 2, 1835 (no figure).
B. Owenii, Pratt, 'Phil Trans.,' 1844.
B. attenuatus, Mantell, 'Phil. Trans.,' 1848.

B. Owenii, Quenstedt, 'Cephalop.,' pl. xxxvi, f. 9, 1849.
B. Puzosianus, D'Orbigny, 'Pal. Franç., Terr. Jur.,' p. 117, pl. xvi, f. 1—6, 1860.

This frequent species, or group of species, varies much in several important characters. The degree of compression is by no means uniform, but I have seen no example of *alveolar* compression approaching to that represented in D'Orbigny, fig. 4 pl. xvi. All my specimens have in that part a slightly elliptical section. In some the sides of the guard are flattened or a little grooved (Pl. XXXI, fig. 77); the apicial region is sometimes unusually compressed, but generally follows the sweep of the sides: the ventral groove near the apex varies from little more than a mere flattening (Pl. XXXII, fig. 79) to a broad furrow (fig. 76, *v'*), a sharp short rift (fig. 77, *v'*), a narrow groove (fig. 76, *v''*, and fig. 78), and a deep lengthened canal (figs. 80 and 81). The general figure, always long, varies in the proportion of length to diameter.

Guard. Very long, subcylindrical, more or less compressed, tapering evenly to a point, grooved on the ventral aspect from the apex through one third or more of the length of the axis; in perfect specimens this groove is often bistriated, or somewhat sharply bordered.

Sections show the axis placed nearer to the ventral surface; in young specimens the compression is considerable, growing less with age; there is sometimes a distinct lateral flattening on the middle part of the guard.

Greatest length observed, in specimens from St. Neot's, 10 inches, of which the axis is 6 inches; the diameter at the alveolar apex 1 inch. In another the diameter at the alveolar apex is $1\frac{1}{4}$ inch.

In a very young state the pearly laminæ about the alveolar apex are sometimes decomposed, and the guard assumes the delusive shape of 'Actinocamax.' A drawing has been shown to me in which this fusiform guard, or 'ossicle,' is represented as separated from the 'nucleus' of the phragmocone, but I have seen no specimen of the kind. Prof. Owen figures ('Phil. Trans.,' 1844, pl. ii, fig. 4) a very young individual, with the guard and alveolar chamber in their ordinary relations. The guard is in this state shorter in proportion than in after-life.

Proportions. In a full-grown specimen from St. Neot's the diameter from back to front, at the alveolar apex, being taken at 100, that from side to side is 90, the axis is 600; ventral radius 45, dorsal 55. The section is slightly oval, the ventral face rather broader than the dorsal.

In a young specimen, 3 inches long, the proportions of the diameters are also 100 to 90; the axis is more excentric than in the older specimen, the ventral radius being only 30, the dorsal 70, the axis 650.

Phragmocone. Known in a crushed state by specimens from near Chippenham. The uncrushed phragmocone has a slightly elliptical section. D'Orbigny gives a very elliptical section (55 to 45). The characteristic angle, as given by D'Orbigny, is 16° 30′. I have no good specimen of this part of the fossil.

Locality. In the Oxford Clay of Wiltshire, Oxfordshire, Northamptonshire, Huntingdonshire. In the Kelloway Rock of Yorkshire. In the Oxford Clay at Vaches-Noires (Calvados), and Marquise, near Boulogne.

Observations. Specimens are often found invested with a sheath of white fibrous matter, externally rough and of granular aspect, within which the true shell is always smooth and shining.

I remark the following varieties:

1. Belemnites Owenii (Puzosianus). Pl. XXXI, fig. 76; Pl. XXXII, figs. 78, 79.

The guard is smooth and always compressed; the apicial furrow distinct or faint, never more than half the length of the axis; alveolar section elliptical. This is the ordinary form from the Oxford Clay of the Midland Counties. In one middle-aged specimen, corresponding to *B. attenuatus* of Mantell, lateral grooves extend all along the post-alveolar tract.

2. Belemnites Owenii (verrucosus). Pl. XXXI, fig. 77.

The surface is ornamented with small, raised, smooth puncta, and undulations composed of these united. The distribution of these may be seen on the ventral face (*v′*), the lateral (*l′*), and the dorsal (*d′*). On the first it will be noticed that the puncta disappear towards the apex, and diverge and disappear on the alveolar region. On the sides they show more of a tendency to gather in linear groups; on the back this concurrence of the puncta makes short undulated ridges, which grow larger, but more dispersed, on the alveolar region. The apex shows signs of very short plications. Only one specimen is known to me, found by Mr. J. E. Walker, at St. Neot's, with *Ammonites Duncani*. The reader may compare the curious granulation in this specimen with that on *B. infundibulum* (Pl. I, fig. 3), with that on specimens of *Belemnitella granulata*, and with the diverging ornaments on a Sepiostarium.

If further research should produce additional specimens, possibly there may be found reason to adopt a specific name for this fossil. But the surface-ornament being at present the only difference observed between this guard and ordinary specimens of *B. Owenii* of the same size, I prefer to mark it as a variety.

3. Belemnites Owenii (tornatilis). Pl. XXXII, fig. 80.

The guard is very smooth, less compressed than in the typical forms; more cylindrical, with a longer, deeper, and narrower ventral furrow (fig. 80). This furrow, indeed, occupies the greater part of the axial length of the guard; in middle-aged specimens an old specimen shows some trace of lateral flattenings. From the Kelloway Rock of Hackness and Scarborough. It is not unlikely that this may be found to deserve to be regarded as distinct specifically.

Belemnites strigosus, n. s. Pl. XXXII, fig. 81.

Guard. Very long, slender, cylindro-conical, compressed, acuminated, smooth, with a distinct longitudinal furrow drawn from near the apex, on the ventral face, through two fifths of the length of the axis, and thence continued in a slighter depression towards the alveolar region.

Transverse sections of the guard show an oval contour, the sides flattened; the ventral face broader than the dorsal; in the alveolar region the dorsal part of the shell is much thicker than the ventral part.

Greatest length of the one specimen seen 7¼ inches, of which the axis is 6¼ inches; greatest diameter $\frac{45}{100}$ of an inch,

Proportions. The diameter at the alveolar apex from back to front ($\frac{4}{10}$ of an inch) being taken at 100, that from side to side is about 80, ventral radius about 40, dorsal radius about 60, axis 1600.

Phragmocone. Unknown. The alveolar section is nearly circular, the angle appears to be about 20°.

Locality. In the upper part of the Oxford Clay, in Cowley Field, near Oxford; one specimen, presented to the University Museum by W. B. Dawkins, M.A., the first Burdett-Coutts Scholar.

Observations. This remarkable fossil carries to extreme length the essential characters of the group of tornatile Belemnites, the cylindro-conical outlines, the slight compression, the apicial groove, and low angle of phragmocone. Having but one example to consider, I am unable to describe the variations due to age and accident, but it would be very agreeable to be furnished with evidence on these points. I have seen no foreign specimens corresponding with this species; but D'Orbigny's fig. 3, pl. xvi, somewhat resembles it. A thin white external layer appears on the specimen, not the fibrous layer noticed in *B. sulcatus* and *B. Owenii*.

Belemnites spicularis, n. s. Pl. XXXVIII, fig. 82.

Guard. Cylindrical (hastate when young), tapering evenly to a point, much compressed to an oval section, with a faint ventral groove drawn from the apex through two fifths of the length of the axis; a few striæ about the apex, especially on the dorsal aspect.

Transverse section oval, the ventral face broader than the dorsal. Substance varied by bands of brown (sepia-tint) and honey-yellow spar.

Greatest length observed 10 inches, greatest diameter 1 inch. Shortest specimen 1 inch long; it is of the form Pl. XXXIII, fig. 82 *l*.

Proportions (old). Taking the diameter at the alveolar apex at 100, the diameter from side to side is 90 +, the axis 1000; the excentricity of the axis variable, in some specimens small, in others the ventral radius = 40, the dorsal 60.

Phragmocone. Incompletely known. The section is elliptical, within a ring of the guard-fibres everywhere of nearly equal thickness; the phragmocone section more elliptical, therefore, than the section of the guard. The angle in one of Lieut. Patterson's specimens appeared to be 18° at the apex, 15° in a more advanced part of the shell. The apex of this phragmocone was placed at about one third of the diameter from the ventral margin.

Locality. Eathie Burn, and Shandwick, on the coast of Cromarty: collected in great abundance and in excellent condition by Lieut. Patterson, who gave me much information as to the circumstances under which he obtained the specimens and the accompanying fossils. He further assisted my researches by presenting to me a set of photographic representations of much interest.

The fossiliferous strata of the Mesozoic system on this coast have been usually described as Liassic, and on a first view of the shale and these Belemnitic fossils such an opinion might be readily adopted. The Belemnite now in question has *analogy* to some of the long species of the Upper Lias, such as *B. tripartitus*, while the next to be mentioned seems to revive the memory of *B. longissimus* of Miller. Their *affinity*, however, is with the long species of the Oxonian stage in the Oolitic system. Among the accompanying fossils I observed in Lieut. Patterson's collection *Gryphæa dilatata*, large and small; *Perna*; *Avicula Braamburiensis*; *Pleurotomaria*; *Ammonites* resembling, if not identical with, *A. vertebralis*, Sow., *A. excavatus*, Sow., *A. flexicostatus*, Phil., *A. plicatilis*, Sow., *A. Gowerianus*, Sow., *A. biplex*, Sow; scales of *Lepidosteus*; cervical vertebræ of *Ichthyosaurus*. The Belemnites form a bed in the shale.

Observations. It is difficult to fix upon any definite characters by which to distinguish this Belemnite from *B. Owenii*, except the greater proportionate length of the axis and the faintness of the apici-ventral groove. The slight striæ about the apex are only seen on one or two specimens.

BELEMNITES OBELISCUS, n. s. Pl. XXXIII, fig. 83.

GUARD. Very long, almost uniformly tapering to a point, compressed, smooth, or with traces of longitudinal interrupted undulations. In some specimens a defined lateral flattening (Pl. XXXIII, *l'*, *l*^{3}). No distinct apici-ventral groove.

Greatest length observed 9¼ inch; greatest diameter in this specimen, just before the conical expansion, less than ¼ an inch. In shorter specimens, 6¼ inches long, the corresponding diameter is nearly the same; in still smaller examples, 3¼ inches long, the diameter is ⅛ of an inch. It seems as if two varieties exist, one much longer in proportion than the other.

Proportions. The normal diameter at the alveolar apex being taken at 100, the transverse diameter is 84; the axis in the longer variety 2000 and more, in the shorter 1500. The excentricity of the axis appears to be very small.

PHRAGMOCONE. I have only been able to observe the cross section, which is less elliptical than the sectional outline of the guard, the guard-fibres being longer on the back and front than on the sides. In this the fossil is analogous to some Liassic forms.

Locality. Eathie Burn and Shandwick, with the last-named species.

Observations. Not only do the unequal proportions of different specimens suggest the idea of a sexual distinction, but the whole group, compared with *B. spicularis*, leads to reflections of the same order. The guard is colour-banded, as is that of *B. spicularis*.

ON A GROUP OF BELEMNITES ALLIED TO *BELEMNITES EXCENTRICUS* OF BLAINVILLE.

Lister, in his 'Historia Anim. Angliæ,' pp. 226-228, has the following description of a Belemnite of this group:—"Titulus xxxi.—*Belemnites niger*, maximus, basi foratâ." Among the remarks on this species we find "Perfricatum cornu combustum aut quoddam bitumen olet." "In tota illa agri Eboracensis regione montosâ, qui *Blackmore* appellatur præcipuè abundant; item in rivulo juxta *Bugthorp*, et alibi reperti sunt." The Blackmore fossils belong to *B. abbreviatus;* a large fragment was above three inches in circumference. Bugthorp is on the Lias.

Lhwyd, in the 'Lithophylacium Britannicum,' notices Belemnites of this group, from the vicinity of Oxford, No. 1667:—*Belemnites maximus oxyrrhynchus*, four inches in girth where largest. Cowley, Bullington, Marsham, Stansford, Garford, the localities mentioned, indicate the species to have been what Miller called *B. abbreviatus*.

Smith, in the 'Stratigraphical System,' p. 50, describes a Belemnite as elongate, rather four-sided, from Wotton Basset and Shippon, in the Coral Rag, p. 43, and another, quite similar, from the Kimmeridge Clay of North Wilts.

Miller described these forms as *B. abbreviatus*; his followers have often assigned that name to a species from the Inferior Oolite.

Young and Bird, in their volume on the Yorkshire coast (ed. 1, 1822), notice a similar Belemnite, and give a figure (pl. xiv, fig. 4), and name it *B. excentralis*, describing it as found in the "Oolite, Upper (Speeton) Shale, and Chalk." This is incorrect, but, as will be seen, the large Speeton Belemnite belongs to the same natural group.

De Blainville, in 1827, describes and figures in his pl. iii, fig. 8, 8*a*, *B. excentricus*, from Vaches-Noires, remarking that Miller's *B. abbreviatus* much resembles it.

D'Orbigny revives Young and Bird's name for a species which he figures (pl. xvii); but in the text (p. 120) he makes no reference to those authors, and uses the name given by Blainville.

In the second edition of the first volume of my work on the 'Geology of Yorkshire' I restored to the great Belemnite of the Malton Oolite the name assigned by Miller, and mentioned the large Speeton Belemnite as *B. lateralis*. An undescribed form in the Kimmeridge Clay of Oxfordshire, and another in the Tealby beds of Lincolnshire, will complete this series of excentral Belemnites, as far as I know them.

BELEMNITES ABBREVIATUS, *Miller*. Pls. XXXIV, XXXV, figs. 84—93.

Reference. *B. niger maximus*, Lister, 'Hist. Anim. Angliæ,' p. 226, 1678.
Belemnites maximus oxyrrhynchus, Lhwyd. (No. 1667.) 1699.
B. excentralis (in part), Young and Bird, 'Geology of the Yorkshire Coast,' pl. xiv, fig. 4, 1822.
B. abbreviatus, Miller, 'Geol. Trans.,' 2nd series, vol. ii, pl. vii, figs. 9, 10, 1823.
B. excentricus, Blainville, 'Mém. sur les Bélemn.,' p. 90, pl. iii, f. 8, 1827.
B. excentricus (also called *excentralis*), D'Orbigny, 'Pal. Franç., Terr. Jur.,' p. 120, pl. xvii, 1842.

GUARD. Cylindrical; sides flattened or somewhat hollowed longitudinally; apex produced, compressed, sometimes incurved; ventral surface broader than the dorsal; a flattening near the apex, on the ventral surface.

Very old specimens have the apicial region much compressed, produced, and incurved; sides flattened by broad, shallow, longitudinal depressions, which continue over a part of the alveolar region, and are there gradually lost.

Young specimens are slightly hastate, very young ones distinctly so, with little trace of the lateral hollow.

Longitudinal sections show the axial line to be very excentric, especially so in the retral part of the guard, and in old specimens considerably curved.

Transverse sections present a somewhat four-sided outline, the ventral surface being struck to a flatter curve than the dorsal, and the sides flat or a little concave.

The length of a very large example is 8 inches; of another smaller, but extending

farther along the phragmocone, 11 inches; the greatest diameter before the conical expansion of the sheath over the phragmocone $1\frac{1}{4}$ inch. The smallest which has occurred to me is little more than 1 inch long.

Proportions in full-sized specimens. Taking the dorso-ventral diameter at the alveolar apex at 100, the transverse diameter is about equal to it, the ventral radius is 32, the dorsal 68, the axis 250, justifying Miller's title of *B. abbreviatus*. In young specimens the axis = 300. Cross sections near the apex show a still greater excentricity, the axis curving towards the ventral surface.

Phragmocone. Conical, a little incurved towards the ventral line, with an almost perfectly circular section; sides inclined at an angle of 18°, except near the apex, where it is greater (above 20°). The septa are numerous, lie at right angles to the axis, with plain unwaved edges, and are penetrated by a marginal siphuncle.

Locality. In the Coralline Oolite and Calcareous Grit of Yorkshire at Malton, Scarborough, &c. In the same strata at Heddington, Cowley, Bullington, &c., near Oxford; near Calne, Weymouth, &c. In France, at Vaches-Noires and Marquise in Oxford Clay. D'Orbigny quotes it from near Moscow. In Oxford Clay, Cowley, near Oxford. In Kimmeridge Clay, Shotover.

Varieties. In progress from youth to age, this Belemnite experiences considerable changes, as may be inferred from what has been said in respect of the guard. Besides these ordinary changes of form and proportion, it appears desirable to distinguish two types of general shape, which occur in large specimens in some degree of relationship to the stages of the strata.

α. Belemnites abbreviatus (oxyrhynchus).

Large, *cylindroidal*, slightly bent, with incurved, produced, flattened apex. Viewed on the front or back, the sides are seen to contract rather suddenly from a cylindroid part to the apex in the architectural form known as ogee (fig. 84, ϕ); viewed sideways, the dorsal outline is continued in a convex form to or nearly to the apex, while the ventral outline becomes concave under the apex (Pl. XXXIV, fig. 84, *l*).

Locality. The Coralline Oolite of Malton, Oxford, and Wilts. An abnormal specimen, which places these characters in a strong light, is presented (Pl. XXXV, fig. 86) from near Oxford.

β. Belemnites abbreviatus (excentricus).

Large, conoidal, with sides almost straight, converging through the whole post-alveolar

space of the guard, the dorso-ventral diameter being in that part much greater than the transverse diameter. The general figure is that of *Belemnites explanatus* (Pl. XXXVI, fig. 96).

Locality. The Oxford Clay, upper part, at Cowley, near Oxford. The Calcareous Grit and Coralline Oolite near Oxford.

This variety agrees well with the description and figure of Blainville ('Mém. sur les Bélemnites'). D'Orbigny makes the phragmocone section to be more elliptical than it usually is, and the axis less excentric than usual; there is also something about the outlines not as we commonly see them.

Remarks on Specimens of *Belemnites abbreviatus*, var. *excentricus*, in the Cabinet of Mr. Wetherell.

The axial line of the guard is in many instances excavated into a canal which grows narrower towards the apex. This is especially the case in specimens obtained from the Drift of Finchley, near London, from which a great variety of fossils of the Oxford Clay and other strata lying to the northward has been obtained by Mr. Wetherell. In the large collection of that gentleman are very many excellent examples of this structure, and by careful study of them in comparison with other undisturbed specimens in the Oxford Clay, Calcareous Grit, and Oxford Oolite, we arrive at a clear view of a very curious subject, of which, at first sight, it might seem difficult to form a correct opinion.

Fig. 88, Pl. XXXV, represents the surface produced by a splitting fracture through a Belemnite in Mr. Wetherell's collection. Fractures of this kind are not infrequent in nature, and are easily produced by intention. The surface thus presented is usually flat and smooth in the ventral portion, as if a natural fissure existed there, but commonly uneven and more or less hackly in the dorsal portion. The hollow left by the spherule is sometimes traceable at the apex of the alveolar cavity, the phragmocone being generally absent in the specimens under consideration, but not seldom the alveolar cavity contracts gradually to the canal without any distinct enlargement at the alveolar apex.

In the figure referred to the canal is seen to contract gradually until it finally dies out before reaching the apex. Examined with microscopic powers of 10 and upwards, the canal is found to be crossed by many ridges at nearly equal intervals, so as to suggest the appearance of an annulated or half-chambered canal, in continuation with the cavity or the spherule of the phragmocone (see fig. 91). The seeming septa of this canal are found by more careful research to be the truncated edges of the successive laminæ of the guard (see figs. *m'*, *m''*), each conspicuous lamina giving origin to one septum. This appears quite certain under the lowest power of a good achromatic microscope, which discloses, moreover, that the laminæ thus referred to appear to be often composed of two or three thinner layers, some dark, others paler, and probably more nacreous in substance.

Following the canal till it closes, the laminæ are seen to lose their truncations, and to acquire the complete curvature.

After careful study of many specimens, no doubt remains in my mind that the canal has been produced by the removal of the apices or terminal parts of the interior laminæ of the guard. This process began at the alveolar cavity; it happened during life, and was occasioned by decay and absorption of the apices in the earlier stages of life.

That these special parts might be of somewhat different composition from the other parts of the laminæ is suggested by some other cases in which terminal porosity and an axial canal have been noticed; and it is quite in agreement with two other circumstances to be observed in these fossils. First, it is to be remarked that the alveolar cavity in these Belemnites often appears marked by the undulated anterior edges of the laminæ of the guard, which terminate in this cavity (see figs. 88, 91, 92), and show white, thin, sparry plates, in consequence of the removal of parts of the laminæ. And again, some of the specimens show a curious appearance of a second canal going from the alveolar cavity (figs. 90 and 92) near its apex. This, being carefully studied, is found to be occasioned by the removal of some of the laminæ of the sheath for a certain space inwards from the alveolar cavity, leaving a kind of slit where the removal has happened.

In later life the deposited sheaths were, in general, not removed by decay or absorption (see figs. 87, 88).

ON THE BELEMNITES OF THE KIMMERIDGE CLAY.

After diligent search in this clay near Oxford, where it is about 100 feet thick, and is pretty well exposed in brickyards and in quarries of the Coralline Oolite, and after a careful search in the escarpment of Portland, I find, speaking generally, a remarkable accordance between its Belemnites and those of the Oxford Clay known as *B. abbreviatus excentricus*, *B. Owenii*, and *B. hastatus*. This analogy was, perhaps, to be expected, inasmuch as Ammonites of the groups of *A. vertebralis* and *A. biplex* occur in both clays.

Taking first the specimens allied to *B. abbreviatus excentricus*, it would, I think, be difficult to assign characters of sufficient weight to claim a specific distinction, though in old specimens the ventral surface is more flattened towards the apex, and in young specimens the whole of the guard is depressed behind the alveolar region. In this respect the young forms closely resemble those of *B. Souichei* (D'Orbigny, 'Ter. Jur.,' pl. xxii, figs. 4—8), which was found in beds referred to the Portland series at Hauvringhen (Pas de Calais), and at the Tour de Croi, near Boulogne. These forms differ from those of the same age from the Oxford Clay and Coralline Oolite.

Next, we may consider the longer forms, like *B. Owenii*, of the Oxford Clay. Of these

some appear to me quite indistinguishable from their analogues in the older deposit; they occur of equal magnitude with them, but not in equal abundance, in the upper part of the Kimmeridge Clay of Shotover Hill, where it was cut through by the railway. One extremely lengthened variety of this Belemnite occurs at Shotover, reminding us of *B. spicularis* from the shore of Cromarty.

Besides these is a young depressed Belemnite much like the young *B. hastatus* of the Oxford Clay; these occur near Oxford and in Portland Isle.

Belemnites explanatus, n. s. Pl. XXXVI, figs. 94, 95, 96.

Guard (old). Conoidal, tapering gradually to a rather compressed apex; sides more or less broadly channelled; ventral aspect flattened and somewhat expanded, becoming concave towards the apex (a few dorsal striæ about the apex are sometimes seen).

Dimensions. Axis about 3 inches; diameter at the alveolar apex 0·85 inch.

(Young.) Depressed, smooth, flattened on the ventral aspect, and hollowed, or marked by a narrow groove towards the apex, which is slightly curved; sides more or less marked by a shallow continuous furrow (a very young form is almost fusiform).

Dimensions. Axis in the smallest about 1 inch, with a diameter of 0·25 inch.

Proportions. Axis in young specimens 400—450. The diameters at the alveolar apex 100 from front to back, 115 from side to side. In old specimens the axis is about 350, the transverse diameter 107, the dorsal radius 64, the ventral 36.

Locality. In the upper part of the Kimmeridge Clay of Waterstock, near Thame. Specimens of different ages — young (not middle-aged) and full-grown—have been presented to the Oxford Museum by Mrs. Ashworth. In the upper part of the same clay at Hartwell, near Aylesbury, with *Cardium inæquistriatum*, *Astarte Hartwelliana*, and *Ammonites biplex*. In the Kimmeridge Clay, upper part, where cut through in the railway-tunnel, at Wheatley, near Oxford.

Observations. On many accounts this form of Belemnite is of interest in the study of the series to which it belongs. On the one hand its resemblance to the older type of *B. abbreviatus* (*excentricus*) of the Oxford Clay and Oolite, and on the other to that of Specton, in Yorkshire (*B. lateralis*), is such as to offer a most instructive example for study, in relation to the derivation of successive specific forms by hereditary transmission with modification. But this must be considered hereafter.

EXPLANATION OF PLATE XXVIII.

Fig

67. BELEMNITES HASTATUS.

Three views of a large specimen from the upper part of the Oxford Clay in Cowley Field, near Oxford; in the Cabinet of Mr. Parker. Fig. 67, *l*, lateral view, showing the rather faint oblique groove; *v*, the ventral aspect, with its deep characteristic furrow, suddenly followed by a shallower channel; *d*, dorsal aspect; *s'*, the cross section of the alveolar cavity; *s''*, section across the expanded part of the guard.

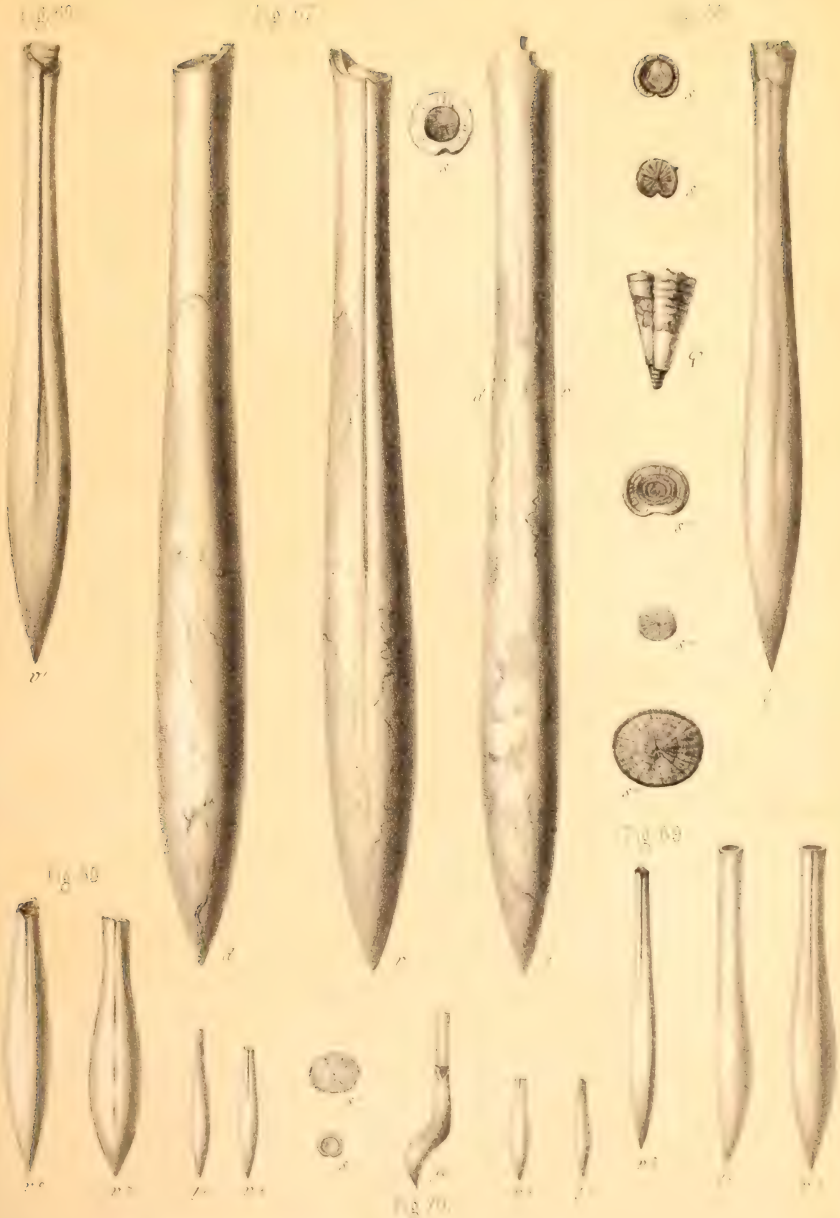
68. Two views of a specimen from the Oxford Clay of Northamptonshire, presented to the Oxford Museum by Mr. Leeds, B.A., of Exeter College.

l'. Lateral view, showing the oblique groove; *v'*, ventral aspect, showing the deep mesial groove expanding retrally; *s'*, the cross section of the alveolar cavity; *s''*, cross section of guard in the narrowest part; *s'''*, cross section in the widest part; *s''''*, cross section near the apex; ϕ, a compressed phragmocone, partly covered by the guard.

69. Young specimens from the Oxford Clay of St. Ives, presented to the Oxford Museum by Mr. J. F. Walker, of Sidney Sussex College, Cambridge.

l^2. Lateral view, showing a recurved apex; v^2, ventral aspect of the same; s^1, cross section of alveolar cavity; s^2, cross section of enlarged guard; v^3, ventral aspect of a younger individual; l^4 and v^4, views of a still younger shell; v^5, l^5, views of a shorter and more bulbous example; v^6, v^7, views of the bulbous variety, with interrupted ventral groove.

70. μ. Deformity. The specimen is from the Oxford Clay of Cowley Field, near Oxford. Cabinet of Mr. Parker.



P. Lackerbauer lith.

EXPLANATION OF PLATE XXIX.

Fig.

71. Belemnites sulcatus. Specimens from the Oxford Clay at Summertown, near Oxford.

v. Ventral aspect of a full-sized specimen; the groove somewhat less distinctly marked than in other cases, and slightly interrupted.

v'. A younger specimen, showing a more marked change of depth in the ventral furrow and its continuation over the alveolar region; *s'*, cross section of the alveolar region of the guard, depressed.

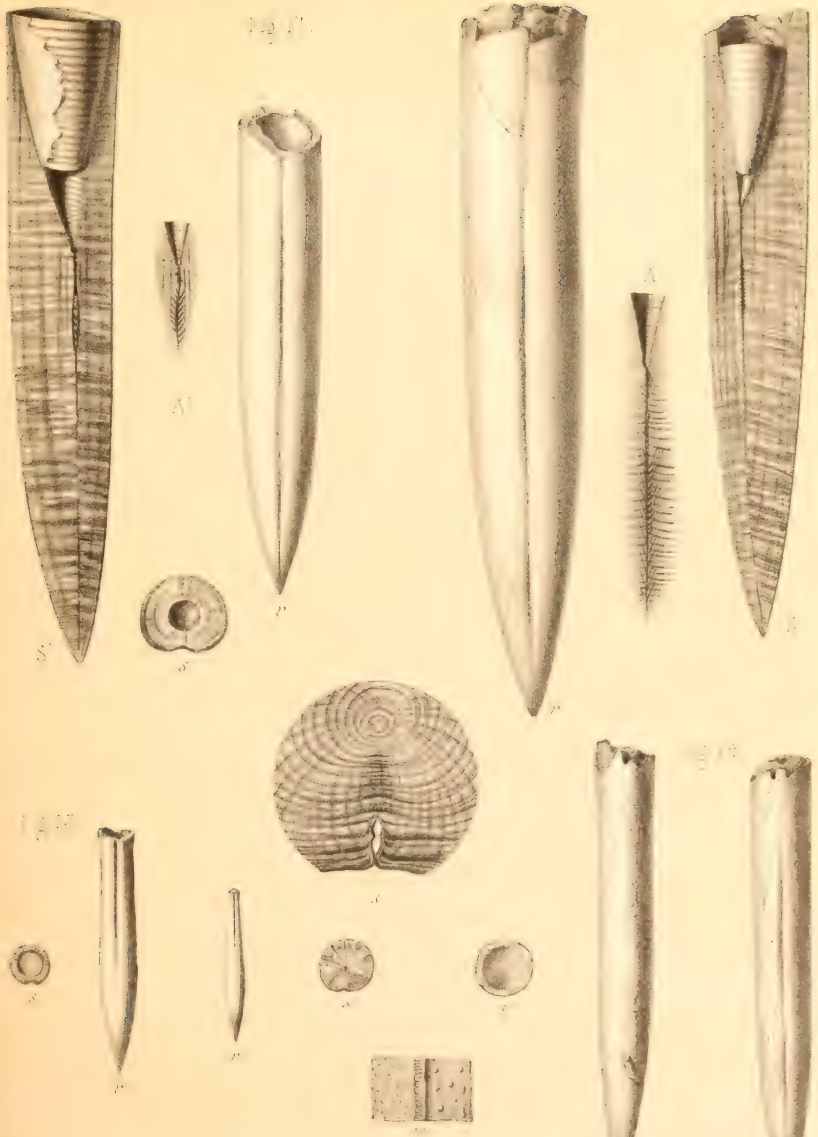
s'. Longitudinal section, from back to front, showing the phragmocone *in situ*, its apicial spherule, and a short lanceolate canal, formed by the decomposition of laminæ, as shown in A'.

s''. Another longitudinal section showing very similar facts; the canal somewhat more extended in A''.

s. Cross section of the guard, showing the inflection of the laminæ to form the ventral groove, and lacunæ of a remarkable kind.

72. Young specimens from Summertown, near Oxford; *l*, lateral; *v*, ventral aspect; *s'*, alveolar cross section, nearly round; *s''*, post alveolar section, nearly round; *m*, magnified surface, the shell dotted with granules, and covered by a partially fibrous layer. Such a layer occurs on some Australian and on some Indian Belemnites.

73. Youngest examples which occur near Oxford, at Cowley, and Long Marston; *v*, ventral aspect, the groove distinct on the alveolar region; *v'*, the still younger shell; *s*, alveolar cross section.

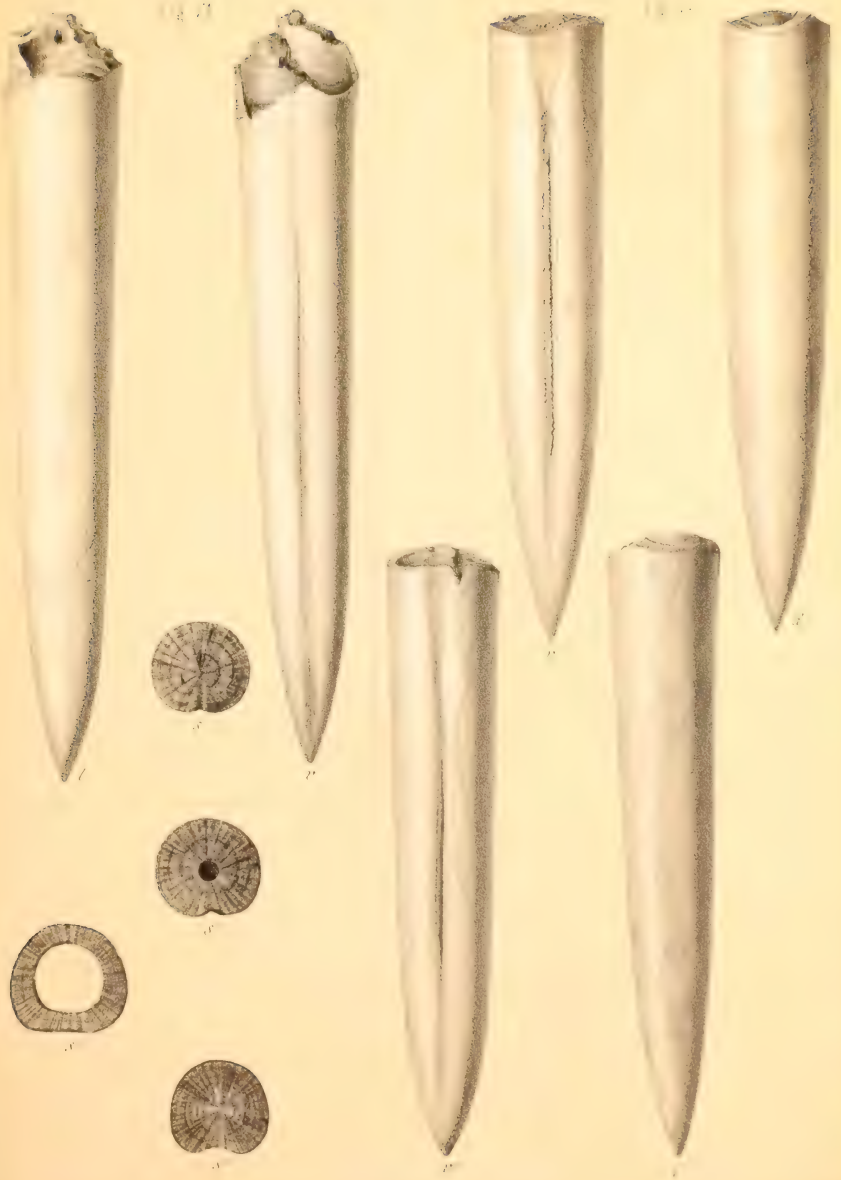


EXPLANATION OF PLATE XXX.

Fig.

74. Belemnites sulcatus. Specimens of full size from the Oxford Clay of St. Neot's; presented by Mr. J. F. Walker, of Sidney Sussex College, Cambridge; *l*, lateral view, showing a very slight flattening; *v*, ventral aspect, showing the groove widening and growing shallow over the alveolar region, partially interrupted toward the apex, with striation parallel to the groove; *s*, cross section of guard, slightly depressed.

75. Specimens from Weymouth. *v'*, ventral surface, showing the groove growing wider and shallower both toward the apex and over the alveolus; *d'*, dorsal aspect; *s'*, cross section of guard nearly round Fig. 75, *l''*, lateral view of another specimen, showing a slight flattening; *v''*, ventral aspect, the groove widening over the alveolar and apicial regions, with striæ of decomposition parallel to the groove; *s''*, alveolar cross section; *s'''*, cross section of guard.



P. Lackerbauer lith.

Imp. Becquet à Paris.

EXPLANATION OF PLATE XXXI.

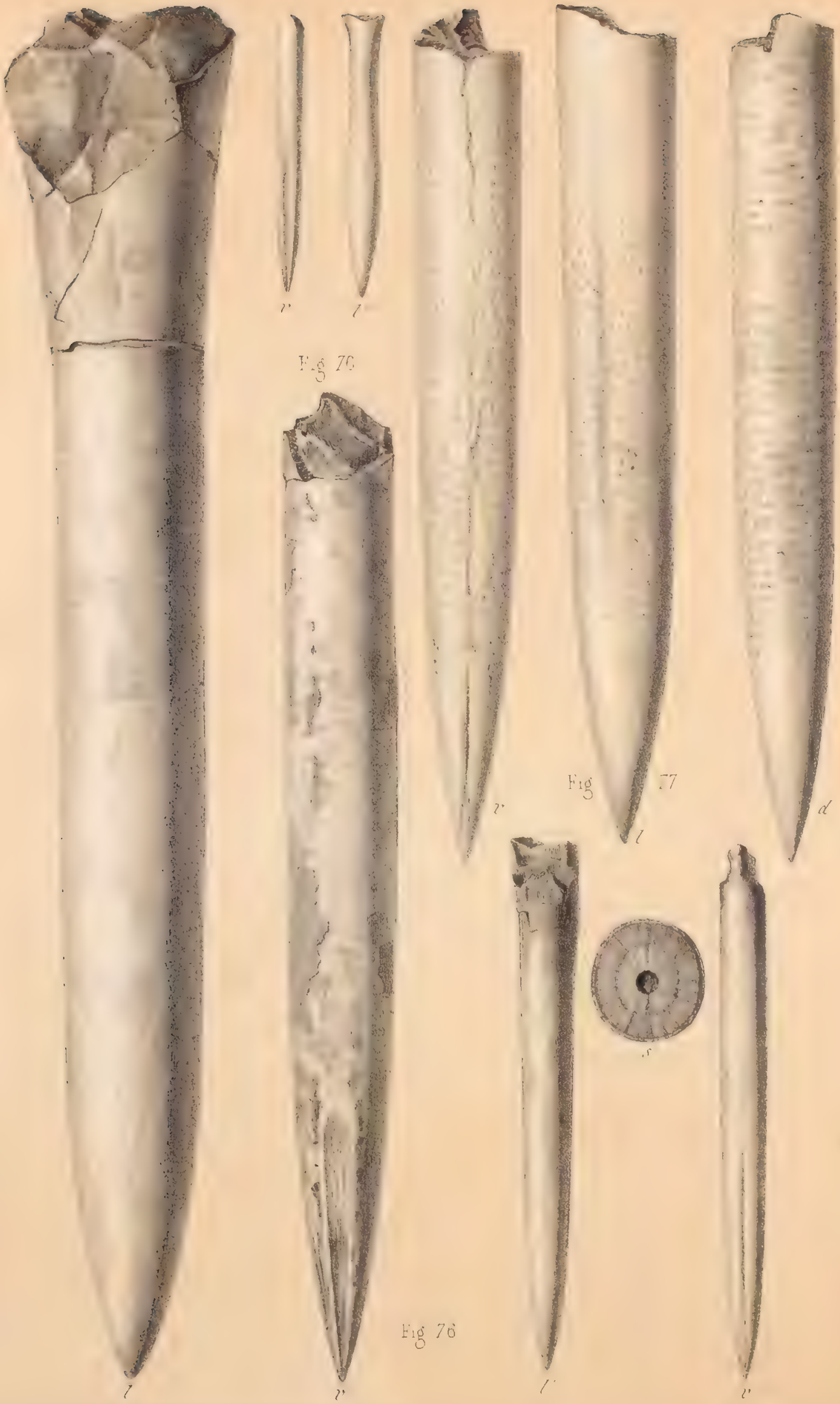
Fig.

76. BELEMNITES OWENII, var. PUZOSIANUS. Specimens from the Oxford Clay of St. Neot's, presented by Mr. J. F. Walker.

l, full-sized specimen seen laterally; *v'*, middle-sized individual, showing the apicial groove distinct; *v''*, younger individual seen ventrally, with its apicial groove; *l''*, side view of the same; *v'''*, still younger example seen ventrally; and *l'''*, seen laterally.

77. BELEMNITES OWENII, var. VERRUCOSUS. From St. Neot's, presented by Mr. J. F. Walker.

v', seen ventrally; *l'*, laterally; *d'*, dorsally; *s'*, cross section in the alveolar region.



P. Lackerbauer lith.

Imp. Becquet à Paris.

EXPLANATION OF PLATE XXXII.

Fig.

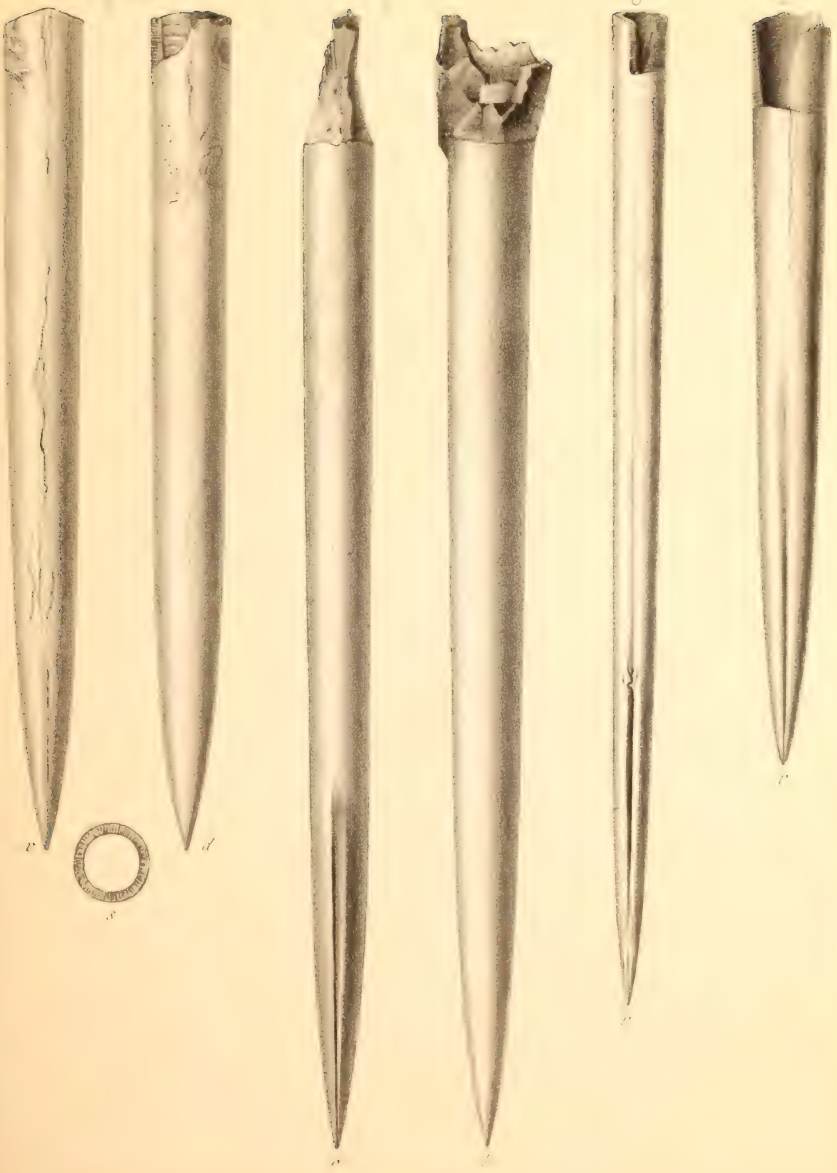
78. Belemnites Owenii, var. Puzosianus. From St. Neot's, presented by Mr. Walker; *v*, ventral face, with strongly marked apicial groove reaching to the point; *l*, lateral view. The cross section is oval.

79. Belemnites Owenii, var. Puzosianus. From St. Neot's; *v*, ventral aspect, showing an almost evanescent apicial depression; *d*, dorsal aspect; *s*, the cross section of the alveolar region.

80. Belemnites Owenii, var. tornatilis. From the Kelloway Rock of Hackness, near Scarborough; *v*, the ventral surface expanding anteriorly; cross section oval.

81. Belemnites porrectus, n. s. From the Oxford Clay at Summertown, presented by Mr. Dawkins; *v*, ventral aspect, showing a strong, sharply cut apicial furrow, and its anterior extension; cross section oval.

Fig. 81.



Lackerbauer lith.

EXPLANATION OF PLATE XXXIII.

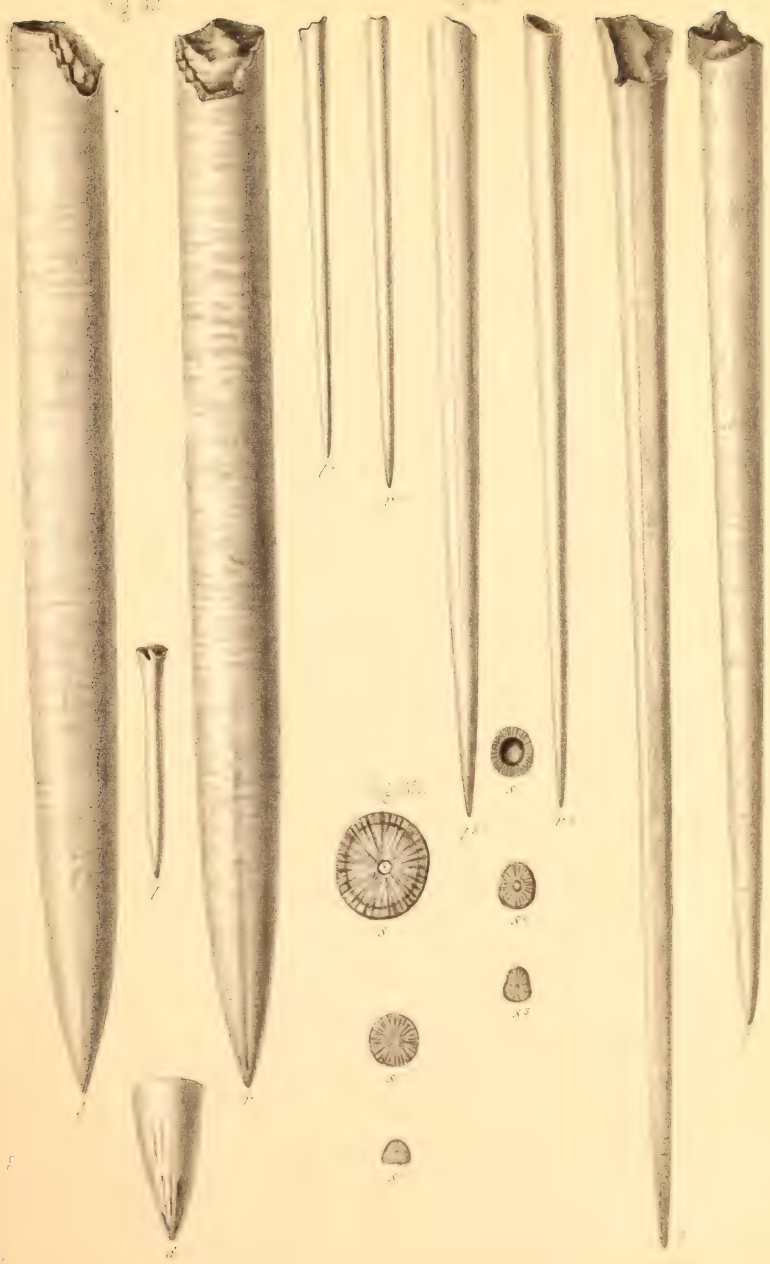
Fig.

82. BELEMNITES SPICULARIS, n. s.

Specimens from Shandwick and Eathie, on the coast of Cromarty, collected by Lieut. Patterson; *v*, ventral aspect of one of the larger specimens, showing the apicial groove; *l*, lateral view, showing the long side flattening, and a trace of short apicial grooves; *d*, the dorsal aspect, marked by some small striæ; *l'*, one of the youngest specimens in Lieut. Patterson's series; *s*, cross section of guard at the alveolar apex; *s'*, section of a smaller specimen toward the apex; *s''*, still nearer the point.

83. BELEMNITES OBELISCUS, n. s.

Specimens collected by Lieut. Patterson at Shandwick and Eathie; *l'*, one of the longest examples, seen sideways; *l''*, one somewhat smaller, *l'''*, still smaller, and l^{iv}, one of the smallest observed; *v'''*, ventral aspect of a small specimen, and v^{iv}, of a still smaller; *s'*, alveolar cross section; *s''*, post-alveolar section across the guard; *s'''*, farther backward in the guard.



F. Lackerbauer lith.

imp. Becquet à Paris.

EXPLANATION OF PLATE XXXIV.

Fig.

84. Large specimens of BELEMNITES ABBREVIATUS, from the Coralline Oolite of Yorkshire and Wiltshire.

l'. Side view, showing a broad lateral depression, and the incurved apex; *v'*, ventral aspect, showing a flattening near the apex. The specimen is from Malton, in Yorkshire.

ph. Showing the phragmocone *in situ*, and the numerous septa, at right angles to the axis. The specimen is from the Calcareous Grit of Seend, in Wiltshire. The drawing was made by Miss Anne Cunnington.

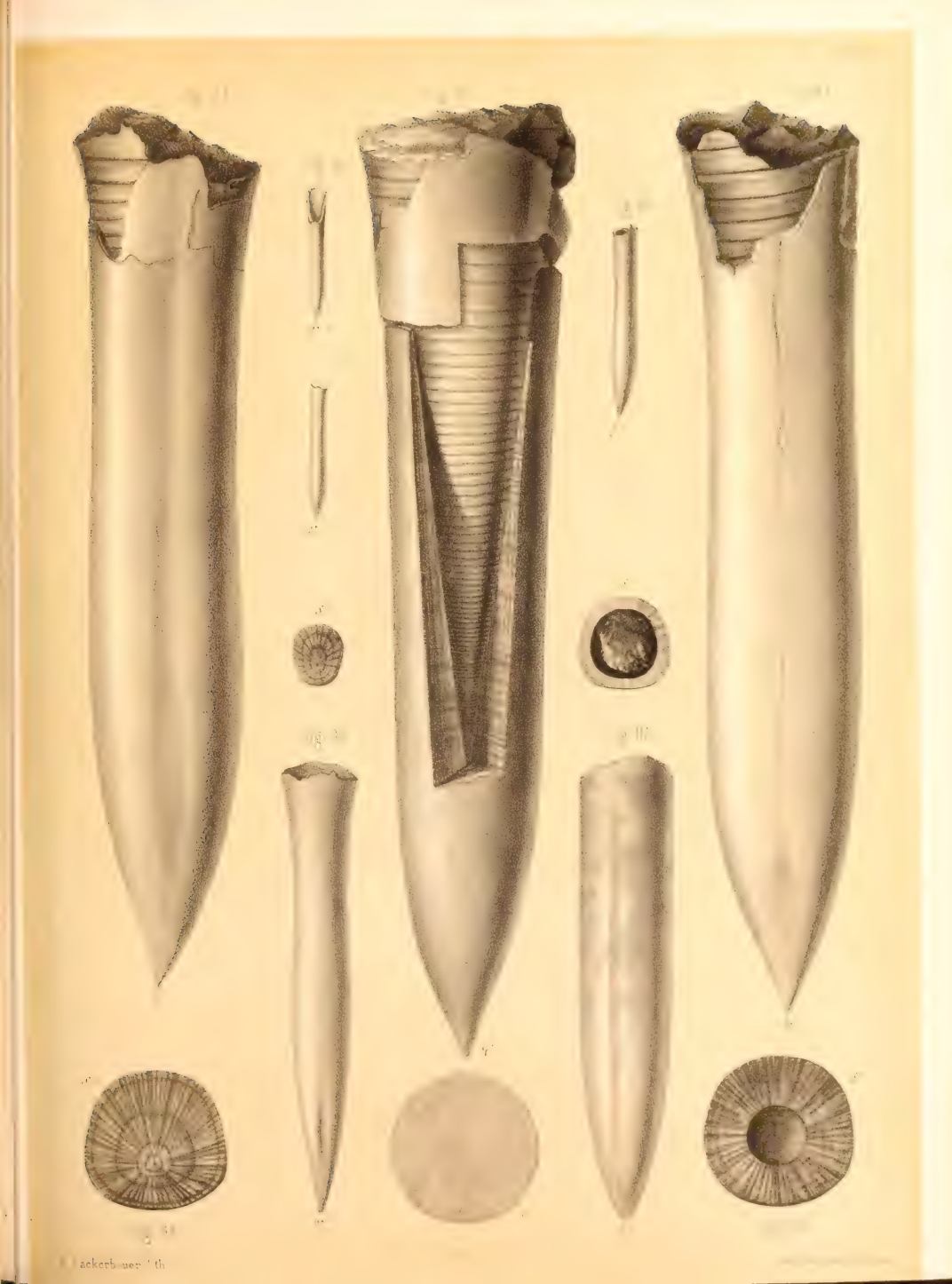
s'. One of the septa seen axially; *s''*, cross section of the alveolar region; *s'''*, cross section behind the alveolus; *s''''*, section near the apex, to show the compression.

85. Younger individuals from Heddington, near Oxford, and Malton, in Yorkshire.

l''. Middle-aged specimen seen laterally; *s''*, alveolar section of the same.

v''. Specimen seen ventrally, with distinct apicial depression; *v'''*, smaller example, a little hastate; v^{iv}, the youngest observed.

l''', A very young specimen seen sideways, a little hastate.



EXPLANATION OF PLATE XXXV.

Fig.

86. A specimen of BELEMNITES ABBREVIATUS (seen laterally), compressed, and unusually bent at the apex; Heddington.

87. Section of BELEMNITES ABBREVIATUS, with the phragmocone *in situ*. The bending of the axial line of the guard is not often so remarkable as in this case, even in old specimens; it is characteristic of full growth.

88. A specimen with less curvature at the point, and less flexure of the axial line. From the Drift of Finchley, in Mr. Wetherell's collection.

89. Natural section to show the decay of the axial laminæ at their apex; Bullington, near Oxford.

The following figures are taken from specimens in the Collection of Mr. Wetherell, from the Drift at Finchley.

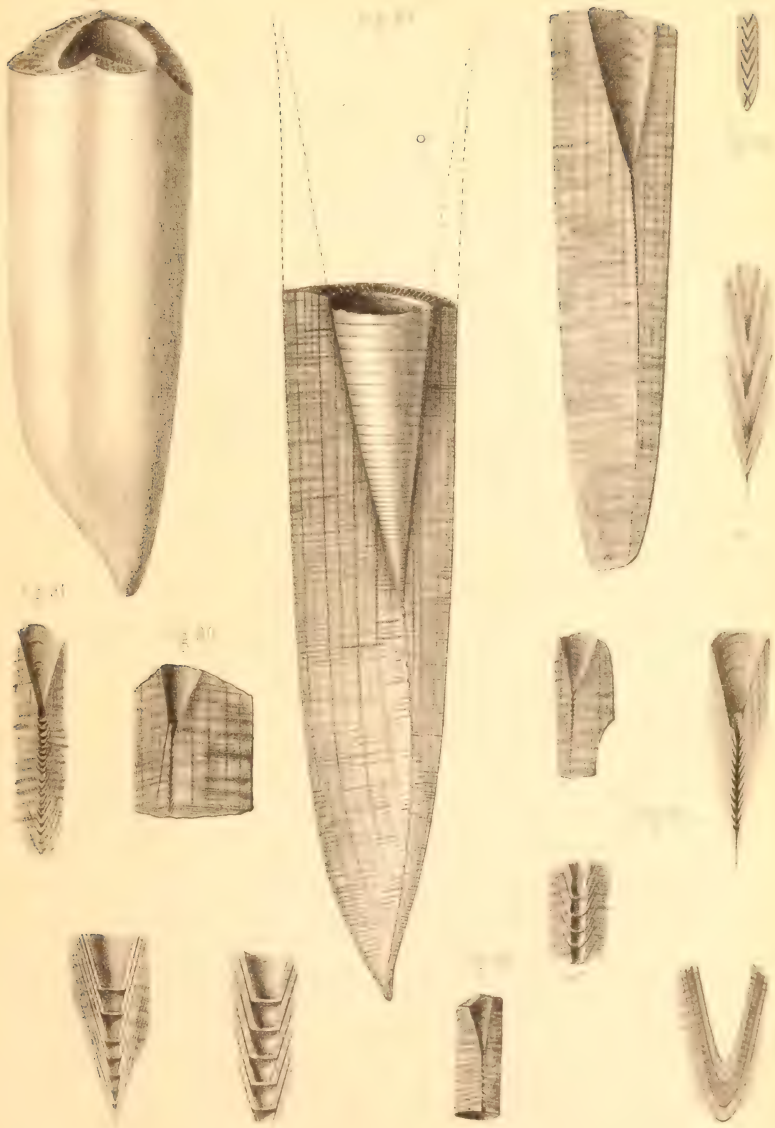
90. Section showing the formation of an axial canal and a vicinal fissure on the ventral side.

91. Section of another specimen.

92. Other sections, in which a small collateral ventral slit appears in the laminæ.

93. Section in which the canal appears interrupted.

m', m'', m''', m^{iv}. Magnified views of the laminæ in relation to the canal.



F. Lackenbauer lith.

EXPLANATION OF PLATE XXXVI.

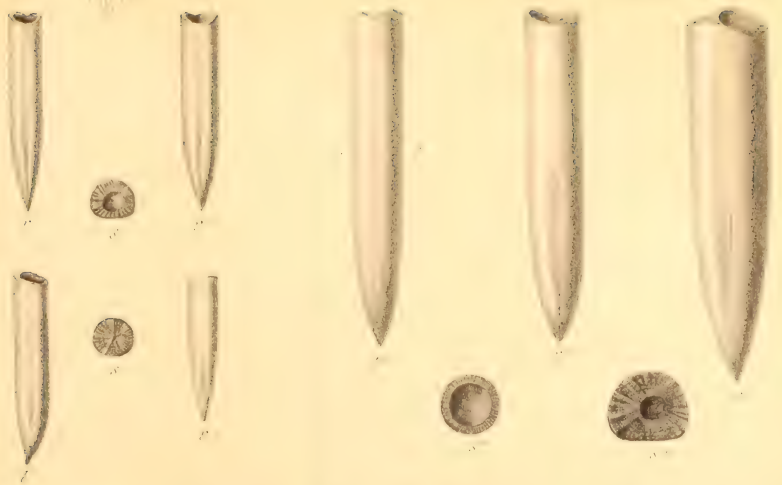
Fig.

94—96. BELEMNITES EXPLANATUS, n. s.

94. Young specimens from Aylesbury, in the upper part of the Kimmeridge Clay.
   v', v'', v'''. Aspect of the ventral face, showing the flattening and slight furrow toward the apex.
   l'''. Lateral aspect, showing the longitudinal depression.
   s'. Section across the alveolar region; s'', section further back on the guard.

95. Specimens more advanced in growth, from Waterstock and the Railway-cutting in Shotover Hill, in upper part of Kimmeridge Clay.
   l^{iv}. Lateral view, showing the longitudinal groove; v^{iv}, ventral aspect of the same, showing the apicial flattening; v^{v}, the same view of a somewhat larger individual.
   s'''. Section across the alveolar cavity; s^{iv}, across the same cavity near its apex.

96. Full-grown individual from Waterstock, upper part of Kimmeridge Clay.
   v^{vi}. Seen on the ventral aspect; the apicial depression wide.
   l^{vi}. The same seen sideways; the lateral depression very distinct, the apex somewhat bent downward.
   d^{vi}. The same seen dorsally, where no trace of furrow appears.
   s^{v}. Section across alveolar cavity; s^{vi}, section behind the alveolar apex; a, the apex seen axially, to show its compression.



P. Lackerbauer lith.

Imp. Becquet a Paris

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1869.

LONDON:
MDCCCLXX.

A MONOGRAPH

OF

THE FISHES

OF THE

OLD RED SANDSTONE OF BRITAIN.

BY

JAMES POWRIE, F.G.S.,

AND

E. RAY LANKESTER, B.A.,

JUNIOR STUDENT OF CHRIST CHURCH, OXFORD, AND COUTTS' GEOLOGICAL SCHOLAR OF THE UNIVERSITY.

PART I (CONCLUDED).—THE CEPHALASPIDÆ.

BY

E. RAY LANKESTER.

Pages 33—62; Plates VI—XIV.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1870.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

disposed concentrically round a middle point, as in *Pt. Crouchii*, but this portion of the shield is apparently elevated into a slight convex boss. The surface-striations of *Pt. rostratus* differ considerably from those of *Pt. Crouchii*. They are very fine, the groovings being only $\frac{1}{100}$th of an inch apart near the centre of the disc, and leaving a rounded dull ridge with crenate margins between them.

Localities.—This species occurs abundantly at Cradley, near Malvern, Herefordshire; and in beds of the same horizon at Whitbach and in the neighbourhood. It is found associated with *Scaphaspis Lloydii*.

3. Pteraspis Mitchelli, *Powrie*. Pl. V, figs. 1, 2, 6, 10, 11.

Pteraspis Mitchelli, *Powrie*. Geologist, vol. vii, pp. 170—172, 1864.
— — *Lankester*. Brit. Assoc. Report, Trans. Sect., p. 58, 1864.

I have not had specimens of this species sufficiently perfect to enable me to characterise it properly. The specimen figured (Pl. V, figs. 6, 10) was briefly noted by Mr Powrie in the 'Geologist,' in 1864, and an outline-sketch was given. The lateral cornua are not seen, but the disc, rostrum, and spine are, to a certain extent. The disc appears to be intermediate in form between that of *Pt. rostratus* and *Pt. Crouchii*. The specimen and others even less well preserved were obtained by Mr. Powrie from quarries in Forfarshire, where *Heterostraci* had been discovered for the first time in Scotland by the Rev. Hugh Mitchell.

A few rhomboidal scales also obtained by Mr. Powrie from this locality (Pl. V, fig. 1) probably belong to this or an allied species.

§ IX. *Sectio* B.—Osteostraci.

We have now to consider the forms which are represented by the original type *Cephalaspis Lyellii* of Agassiz, which have bone-lacunæ as structural elements of their shields, a tubercular ornamentation of the surface, and mesially placed orbits. The bodies, with the scales and fins, of some of these fishes have been discovered, and are of the greatest interest, but are not sufficiently common or well known to allow of their being used in framing generic and specific distinctions. The division into genera of the *Osteostraci* is based upon the presence or absence of plates in addition to the cephalic shield, and upon the form and relation of this additional piece with regard to the cephalic shield.

The species are most safely distinguished by the character of the superficial tubercular ornamentation; where that is not possible the general outline of the head must be

depended on. But this is a very unsafe criterion, since, owing to the fact of its being very thin, the shield is liable to the most deceptive distortion. Examples of this are familiar to all who know the fish-heads of the Herefordshire Cornstones. So great is the uncertainty in this matter, that I have had much doubt as to the distinction between the Scotch type-specimen of *C. Lyellii* in the British Museum and another Scotch specimen in the museum at Arbroath, and again between these two and the common Herefordshire species included by Agassiz under *Cephalaspis Lyellii*.

Before proceeding to the description of genera and species, in which I shall rely more on the figures than on the words which can be used to describe them, remembering the motto inscribed by the illustrious Della Chiaje in one of his works, "Res non verba," a few general remarks may be offered with regard to the variations of the shield in structure and form, and also a general description of the body-scales and fins.

1. *Variations in the Intimate Structure.*—For a general description of the minute structure of the test in the Osteostraci I must refer back to page 7 of this Monograph, and also to the plate of microscopic drawings and explanation accompanying this part. The microscopic structure of *Cephalaspis Lyellii* and of the large form called *Cephalaspis asterolepis* by Dr. Harley[1] has been carefully studied, but of other species proper material has not come to hand. In *Auchenaspis* and *Didymaspis* I was able to ascertain the presence of bone-lacunæ of an elongated character, with their long axes crossing in the various layers, thus giving the appearance of cross-hatching described by Prof. Huxley. In the so-called *Steganodictyum Carteri* to which I called attention in the 'Quart. Journal of the Geol. Soc.,' 1868, p. 547, as being really an Osteostracous Cephalaspid (the *Steganodictyum Cornubicum* having been pronounced a Pteraspid by Prof. Huxley and Mr. Salter), I have found small bone-lacunæ with very numerous fine canaliculi interlacing in every direction. The lacunæ were not elongated, and were smaller in size than those in the lower portion of the shield of *Cephalaspis Lyellii*.

2. *Variations in the Surface-markings.*—The tubercular ornamentation which appears to be a constant characteristic of this section of the ancient Sturgeons presents considerable diversity of arrangement. In some cases each hexagonal area (described at page 8, and figured in Pl. XIV, fig. 7), supports a simple tubercle or one large tubercle and a smaller one. In other cases there are many of these tubercles, of a smaller relative size, placed irregularly on the area; or, again, there may be a central tubercle surrounded by six or more smaller ones, like a miniature volcano with its secondary cones. At the margins of the shield, and especially on the 'cornua,' the tubercles become very closely packed and elongated. The tubercular ornamentation is continued on to the under surface of the shield, to some extent, along the enlarged margin and its posterior expansions (see woodcut, fig. 12), just as in *Pteraspis* the striations of the surface were shown to continue on part of the inferior surface of the rostrum, and along the margin formed by the hollow cornua. The meaning of this

[1] This species is not to be distinguished from the *Cephalaspis Salweyi* of Egerton.

continuation of the superficial marking to the inferior surface is, of course, simply that the parts of the inferior aspect of the shield so marked were as anatomically superficial as the tuberculated superior surface. The recognition of this fact is important, as being inconsistent with the supposition of a mouth reaching along the margin of the fish's head, which involves the notion that the upper jaw is formed, as it were, by the margin. Probably no one acquainted with recent forms allied to the *Cephalaspidæ* would hazard such a conjecture. The woodcut, fig. 15, is interesting to compare in the consideration of this matter. The tubercles on the margin of the shield sometimes assume a very spinous or even tooth-like form, *e.g.* in the species *C. asper* and *Eukeraspis pustulifer* (see woodcut, fig. 23), and hence it is not surprising that detached portions of the margin with its tubercles should have been mistaken for bits of fish-jaw. On the inner side of the cornua the tubercles are modified; even the common Herefordshire species presents the form of long tooth-like excrescences, and in *C. asper*, one of Mr. Powrie's discoveries, the scales, which are always tuberculated in the *Osteostraci* like the head-shield, present very close-set and acute spinous ornamentation (Pl. X, fig. 5).

The tubercles themselves are generally round, with a bright and smooth surface, similar to that of the intervening matter, both resembling in their microscopic structure the 'cosmine' of Prof. Williamson. In one species discovered by Mr. Lightbody, of Ludlow, in the beds of the Tilestone group which have furnished the *Auchenaspis Salteri*, the tubercles have a curious truncated appearance, giving them a really crater-like form. In other parts of the same head-shield, or on what are perhaps additional posterior plates, the tubercles are intersected by a network of coarse grooves forming an irregular crocodiloid pattern. The tubercles of *Auchenaspis* are large in proportion to the size of the shield; those of *Eukeraspis* very closely set and small, though not so small relatively as those of *Cephalaspis Powriei* and *Cephalaspis Agassizii*.

The exceeding rarity of the preservation of the tuberculated surface in specimens of *Osteostraci* must be borne in mind. I have only one specimen of the common Herefordshire species that shows them at all well. It is much more difficult to get this surface in a state of preservation than that of the Pteraspids, difficult as that is to obtain. Frequently the lower layers of the Osteostracous shield are preserved, and have been mistaken for the true superficies by Prof. Agassiz and by many collectors. When the matrix is of such a character as to preserve well the test, the shield is very generally crushed and distorted, so that we are almost invariably offered a choice of evils.

There are no 'pits' on the surface of the Osteostracous shields analogous to those described by me in the genera *Scaphaspis* and *Pteraspis*, which seem to represent the lateral line.

The scales, like the head-shields in *Cephalaspidæ*, are to be looked upon as bones or parostotic formations, and not as mere scales. They belong to the aponeurotic region spoken of by Mr. Parker in his great work,[1] and, the ganoin-layer being absent from them,

[1] 'On the Shoulder-girdle,' &c. (Roy. Soc.), 4to, 1848.

there may have existed a separate overlying set of scales, though the ornament renders this unlikely.

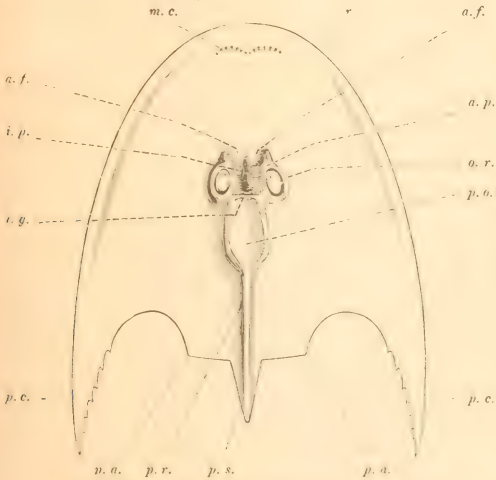
Of the Form and Construction of the Shield.—In the *Osteostraci* the shield is very greatly convex when not distorted by pressure, attaining an almost hemispherical curvature in some parts. The test bends over at the margin, and is continued inwards, forming a hollow rim to the shield, which at its posterior angles widens out, as seen in the woodcut (fig. 12), forming what may be termed the 'lateral floors' of the cephalic shield. Since these inflections terminate abruptly, there is no *general* floor to the cephalic box as far as calcareous matter goes. It was completed by a tough skin and a mouth, no doubt. The test in *Cephalaspis* is, moreover, reflected from the margin and floor against the roof of the shield, forming a lamina of great tenuity subjacent to the upper tuberculated lamina which forms the roof of the shield. This secondary 'roof'[1] thins out towards the centre of the cephalic plate, and probably became membranous (see woodcut, fig. 13, section; and woodcut, fig. 12, inferior aspect). The hollow rim must be compared with the hollow cornua of *Pteraspis;* and probably like them it had apertures at its posterior angles, close to the attachment of the pectoral appendages (see fig. 16). In the genus *Cephalaspis* proper, which may be placed subgenerically as *Eucephalaspis*, the shield is ellipsoid in its anterior portion, and is produced into cornua of considerable length at each posterior angle. The median portion is also extended in a backward direction, and in the middle line presents a short spine. In the subgenus *Hemicyclaspis* the cornua are not developed, nor is the median portion markedly produced, the whole shield having a truncated hemispherical outline. In the subgenus *Zenaspis* the cephalic shield has the character of that of *Eucephalaspis;* but one at least, and perhaps more, scutes placed dorsally in the median line succeeded it. This arrangement paves the way to Sir Philip Egerton's genus *Auchenaspis*, in which the shield is identical with that of *Eucephalaspis*, supposing its median posterior portion but slightly developed, and a large neck-plate soldered to it. The subgenus *Eukeraspis*, which I have associated with *Auchenaspis*, though no neck-plate has been yet found attached to the cephalic portion, possessed exceedingly long cornua, extending backwards to more than double the length of the shield itself. Other characters of importance render it desirable to form this subgenus of *Auchenaspis*. The genus *Didymaspis* had a neck-plate fully as large as the anterior or cephalic plate, which appears to have possessed no cornua. The neck-plate may perhaps be regarded as representing in those genera which possess it the distal portion of the compound shield of *Pteraspis*, though it is not advisable to trace a very close morphological relation between the two groups *Heterostraci* and *Osteostraci* in the details of the construction of their superficial armature. The remarks which were made (p. 17) with regard to the nature of the suturing or fusion of the pieces of the shield in the Pteraspids apply to the similar cases among *Osteostraci* with equal force, the difference of histological composition in the two cases being, however, duly taken into consideration.

The position of the orbits, and certain very remarkable concavities and eminences

[1] Observed by Prof. Huxley.

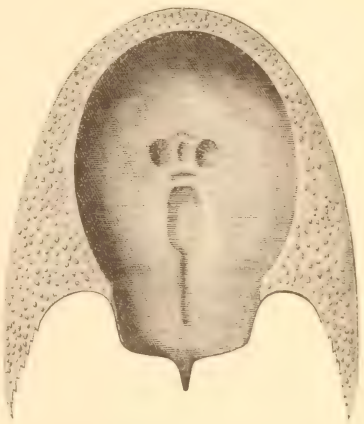
between and in front of them, are very constant in the Osteostracous shields. The structures alluded to are seen in the woodcut (fig. 11), which has been carefully constructed from a remarkably well-preserved concave cast of the parts in question of a specimen of *Cephalaspis Agassizii*. Between the orbits is a well-marked tubercle, which I call the *interorbital prominence* (*i. p.*). In front of each orbit the material of the test is also raised into a projecting mass, which is to be called *the antorbital prominence* (*a. p.*). Between the two *antorbital prominences* is a very deep depression of the shield, divided beneath the superficial lamina into two parts by a narrow septum continued from the *interorbital prominence*, which is hollow. The two cavities thus formed (see also Plates IX. fig. 2, and Pl. XIII, fig. 4 *a*) are the *antorbital fossæ* (*a. f.*).[1] The material of the shield forms a somewhat elevated ring round each eye, which may be

Fig. 11.



Restored outline sketch of the head-shield of *Eucephalaspis Agassizii*.

Fig. 12.



Diagrammatic view, from below, of the cephalic shield of a *Eucephalaspis*.

a. f. antorbital fossæ, *i. p.* interorbital prominence, *o. r.* orbital rings, *i. g.* interorbital groove, *p. o. v.* post-orbital valley, *m. c.* marginal cells, *p. c.* posterior cornu, *p. a.* posterior angle, *p. r.* posterior ridge, *p. s.* posterior spine, *r.* rim or margin.

designated the *orbital ring* (*o. r.*). Posterior to the *interorbital prominence*, and more strictly placed between the two orbits, which in some specimens it has the appearance of uniting, like the nose-saddle of a pair of spectacles, is a deep well-defined impression, which may be distinguished as the *interorbital groove* (*i. g.*). Immediately behind this, and reaching backwards towards the posterior spine, as it approaches which it narrows,

[1] These occupy such a position as to suggest a connection with the olfactory organ, which hence may be inferred to have been double in these fishes—a fact which makes it certain that, though these are the earliest fishes yet *found*, they are very far indeed from the *first* Vertebrates, their ancestors or forerunners; they are also, it seems likely, far in advance of the 'Protamphirine' of Haeckel.

is a flattened oblong area, which is even a very little concave, and may be named the *postorbital valley* (*p. o. v.*). Quite anteriorly and near the margin or rim of the shield two round masses are indicated by dotted lines (*m. c.*). Like the double antorbital hollow, they do not appear superficially, but are very constantly to be observed in specimens, since the superficial portion of the test is so rarely preserved. They are really areas in which the concavity of the inferior aspect of the shield is not maintained in its regularity, but increased between the two laminæ. In *Eukeraspis* (Pl. XIII, fig. 12) they are very markedly developed all round the margin of the shield, and are very conspicuous modifications of its structure. They may be termed *marginal cells*. It may, perhaps, seem superfluous to designate each of these parts by a distinct name, but it is of great importance that they should be clearly recognised and distinguished, since they are present or are represented in all genera of *Osteostraci*, and were they better known in all the species would undoubtedly furnish valuable diagnostic characters by their modification and variation. A glance through the plates will enable the reader to recognise some of them

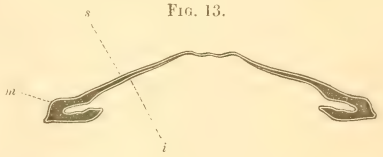


FIG. 13.

s. superior lamina. *i.* inferior lamina. *m.* margin.

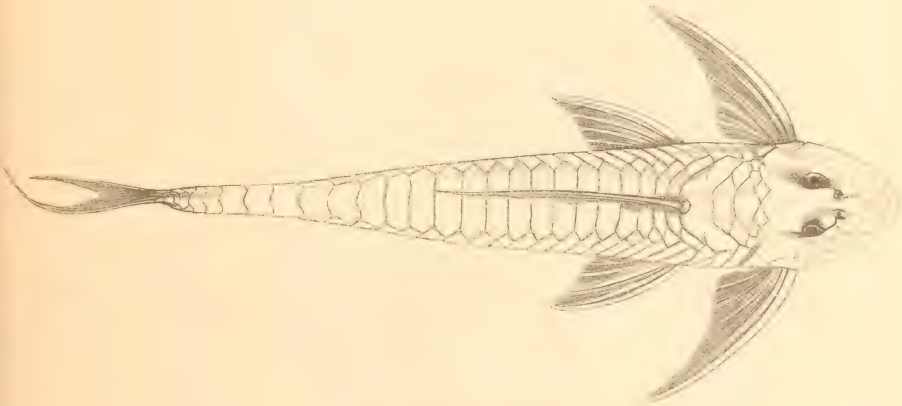
in nearly every specimen figured, whilst in most the crushing or fracture of the specimen has obliterated some or other of them. The letters *p. c.* indicate the *posterior cornua*, *p. r.* the *posterior median ridge*, *p. s.* the *posterior spine*, and *p. a.* the *posterior angles of the shield*. It would be important to ascertain with what soft parts these protuberances and cavities were connected, and what relation they may have to similar structures in recent fish; but into this inquiry, as well as that relating to the 'central pit' in front of the disc of *Cyathaspis* and *Pteraspis*, I do not propose now to enter, such an investigation being unnecessary in a descriptive monograph of fossil remains.

Scales, Fins, and Form of the Body in Osteostraci.—The two specimens of *Cephalaspis* figured by Agassiz, in his 'Recherches sur les Poissons fossiles,' gave some evidence as to the nature of the parts of the body in these fish, but our knowledge on these matters has been very much extended by the discoveries of my friend and coadjutor Mr. Powrie in Forfarshire, and by other 'finds' in the same district. I do not at all suppose that the details ascertained with regard to the genus *Cephalaspis* are necessarily true for all the allied forms; indeed, the existence of large dorsal plates in the subgenus *Zenaspis* clearly shows that they are not; but as yet the only *Osteostraci* (the only *Cephalaspidæ*, indeed) of which we have remains of the body (excepting a few scales of *Pteraspis*) are *Cephalaspis Lyellii*, *C. Pagei*, and *C.*

Powrici, and others less satisfactory of the same subgenus. What is said here, therefore, must be accepted as based merely on that limited amount of evidence.

In the first place, it is probably a very constant character that the scales of the body present the same tubercular ornamentation as do the head-shields, since it is observed in all the specimens discovered, and is parallelled in the *Heterostraci* by the identity of ornamentation of the scales and shield of *Pteraspis*. The body in those forms known is very thin, small, and tapering, probably embracing but a small portion of the viscera, which were rather covered in by the so-called *head*-shield. The scales (in *Eucephalaspis*) are in four chief series on either side the median line—a *dorsal*, of oblong rectangular form; a *lateral*, of much longer proportions; a *marginal*, projecting from these at an angle; and a *ventral*, meeting in the median line on the ventral aspect, as do the dorsal on the dorsal aspect. In *Eucephalaspis* the scales are in a *single row* in each series, with the exception, probably, of the ventral series, where they appear to be broken up into four or more (Pl. XI, fig. 2).

Fig. 14.

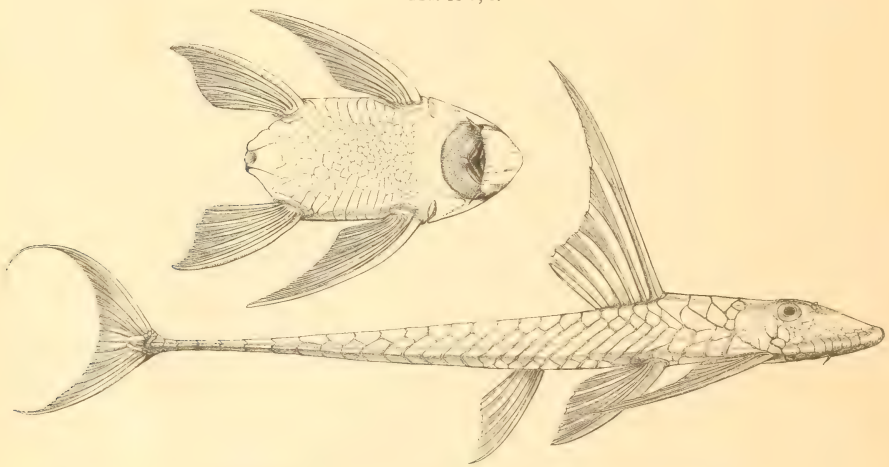


Loricaria platystoma, Günther.

The specimen referred to in the Arbroath Museum is the only one which clearly shows this remarkable series of scales. Posterior to the dorsal fin the three well-defined rows of scales, visible when the fish is in a lateral position, become broken up and confused in a continuous armour of rhomboid scales. The manner of the breaking up of the series I do not know, since no specimen is well preserved in this part; but it may be conjectured from the numerous analogous cases among Siluroids. Prof. Agassiz was led to suppose that the dorsal series of scales was double on either side, by the observation of the rhomboid scales belonging to the region behind the dorsal fin, and probably also by Mr. Dinkel's very imaginative representation of the profile specimen (fig. 1, pl. 1, in the 'Poissons fossiles;' and in 'Siluria,' 1867, pl. 36, fig. 3), now in the possession of Sir Philip

Egerton. I was completely astonished on comparing the specimen kindly lent to me by Sir Philip with the figure which has been so widely copied. The specimen presents the *concave* surface of half of the head-shield and the inner surface of the body, showing well the large lateral scales; but none of the detail as to dorsal scales which the artist has drawn is to be seen, and there is no real foundation for assigning two rows to each dorsal series of scales. In *Pteraspis* undoubtedly there are many dorsal rows of nearly equilateral rhomboidal scales, and one may be quite prepared to find that such was the case in some *Osteostraci*. The restored outline sketch (woodcut, fig. 16) of a *Cephalaspis* (*Eucephalaspis Lyellii*) gives a better notion of the relative proportions of the scales than mere words can, especially when compared with some of the plates. But it is necessary to state again that the *way* in which the series of scales break

Fig. 15 *a*, *b*.



Loricaria platystoma, Günther, a recent fresh-water fish, of the Siluroid group, from Surinam.[1]

up at the dorsal fin is not known. The scales are thicker and broader in *C. Lyellii* than in *C. Powriei* relatively. They are deeply imbricated in each series, and have a considerable thickness of structure, histologically agreeing, as far as I have been able to examine them, with that of the head-shield. The body in vertical transverse section presents a triangular form as seen in fig. 17. It appears that the scales of the lateral series admitted of considerable movement of the body, though so large and strong; for, whereas in the specimen drawn in Pl. VIII they are inclined posteriorly, in that drawn in Pl. XI they present exactly the opposite direction. This is, no doubt, due to muscular contraction, the

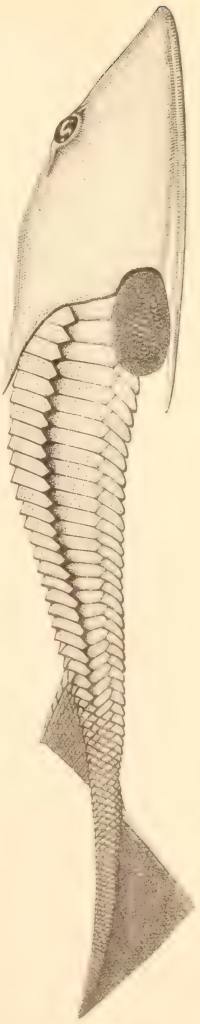
[1] I have to thank the Secretary of the Zoological Society for the use of the cuts, figs. 14 and 15, which illustrate a paper by Dr. Günther.

scales becoming overlapped to a greater or less extent, according to the angle assumed. Probably each scale indicates a sclerotom.

The fins are two pectorals of very peculiar form and character, a dorsal placed posteriorly and a caudal. The dorsal and the caudal were known to Prof. Agassiz; but the pectoral appendage, though indicated in Mr. Dinkel's drawing in the 'Poissons fossiles' of the Glammis specimen (which has since been chiselled so as to obliterate these organs), are not described in the letter-press. Mr. Powrie called attention to these strange pectoral organs in the 'Geologist,' 1861, p. 137, and they are well seen in some of his beautiful specimens illustrated in the plates of this work. They differ from the other fins in presenting no trace of fin-rays or of the fine scales which extend upwards from the base of the dorsal and caudal. They are simply ellipsoid expanses, with some calcareous matter in their structure, which has caused them to be preserved, and has rendered visible, especially in fig. 1, Pl. X, a kind of reticulate or areolate markings, quite peculiar to them. The character of these fins differing so much from that of the other fins tends to suggest that they may have had other functions than that of mere locomotion, and it seems not at all improbable from their position that they may have been efficient in causing currents of water to pass to the branchial organs covered in by the great head-shield (whose outlets are indicated by the lateral perforations in the shield of *Pteraspis*), and have thus aided respiration as well as locomotion, as is observed in the fry of Teleostean fishes at the present day with regard to the pectoral fin. These pectoral organs are mentioned here especially because it seems hardly doubtful that they are characteristic of the group, possibly also of the *Heterostraci*; it is not likely that they were developed in but one single genus of the closely allied series classed as *Osteostraci*.

A very remarkable specimen of shagreen-like structure has been discovered by Mr. Powrie in Forfarshire, in beds which have furnished *Cephalaspis*. As I have not been able to assign it to Cephalaspidian fishes, though it may possibly be connected with them, I only allude to it here. It consists of a surface covered with minute spinous tubercles, the whole having the appearance of a fossilized piece of shagreen, and its shape

FIG. 16.



Restoration of *Eucephalaspis Lyellii*.

is more or less that of a Cephalaspid with head and body. The spinous tubercles on some species of *Cephalaspis* (Pl. X, fig. 5) suggested the idea that this might belong to the lower surface of one of these fishes, covering in the ventral aspect of the head and the ventral series of scales; being detached, as it were, in this part of the animal, but adhering closely to the deeper aponeurotic layers of the exoskeleton in the superior parts, and forming the characteristic tuberculated surface of the shield and scales. There is, however, no proof of its connection with these fishes, and it seems more probable that it belongs to some early representative of the Sharks and Rays (representative, perhaps, only in the character of its dermal ossifications) than that it is the ventral covering of a Cephalaspid. Its mention here may incite investigation and lead to the discovery of specimens showing clearly a connection, but as matters at present stand there is not sufficient evidence to justify the introduction further of the specimen into these pages.

Value of Specific and Generic Distinctions.—Before proceeding to describe the genera and species of *Osteostraci*, I would allude to the principles which have determined me in forming genera and species. In the first place, as to species. It appears to be better for the end of advancing knowledge to signalise a doubtful form by a name, than to pass it over as a possible variety or questionable species. The error of associating under one head what are really distinct species is undeniably as great as that of founding new species on specimens which may eventually prove to be imperfect conditions or locally distorted states of species already known. The object to be held in view is to attract attention to the matter in doubt, and this can be best done by the use of *a name*, which has only to be rescinded in the event of further discovery rendering it desirable so to do. The object of a descriptive work such as this, in which the material is fully placed before the reader, is to point out distinctions and peculiarities in the various specimens studied, and it seems better in this case to err on the side of division than on that of fusion.

The only use that can be made of generic divisions in the case of fragmentary fossil remains is to place those things which are alike in the same group, and those which differ in different groups, thus pointing out the gaps in our knowledge of the continuity of forms. If our knowledge were more complete there would be greater difficulty in indicating groups, a fact which is true for all groups of organisms. Grouping is facilitated by the occurrence of gaps that are not real, but are due to our imperfect knowledge.

List of Species of Osteostraci, *arranged in Order of their Occurrence.*

Upper Silurian. *Thyestes verrucosus*, Eichwald; *Cephalaspis* (?) *Schrenkii*, Pander.

Downton Sandstone. *Eukeraspis pustuliferus.*

Passage beds. *Didymaspis Grindrodii, Auchenaspis Salteri, Av. Egertoni, Cephalaspis* (*Hemicyclaspis*) *Murchisoni, C. Lightbodii.*

Lower Devonian (of Devonshire and Cornwall). *Cephalaspis* (?) *Carteri.*

Cornstones (West of England). *Eucephalaspis Agassizii, Zenaspis Salweyi.*

Lower Old Red Sandstone (Scotland). *Eucephalaspis Lyellii, E. Powriei, E. Pagei, E. asper.*

Descriptions of Genera and Species.

Genus 1.—Cephalaspis, *Agassiz*. Poissons fossiles, vol. ii, p. 149, 1835.

Derivation.—κεφαλή, the head; ἀσπίς, a shield.

Characters.—Scutum cephalicum simplex semicirculare.

The genus *Cephalaspis*, as here indicated, may be conveniently split into three subgenera.

1. Eucephalaspis.[1]—Scutum postice cornibus lateralibus instructum, in medio aliquantò productum.

2. Hemicyclaspis.[2]—Scutum sine cornibus lateralibus: postice subtruncatum.

3. Zenaspis.[3]—Scutum Eucephalaspidis scuto simile: scutellum dorsale (vel scutella) post scutum cephalicum positum.

It seems to be a clearer representation of the relations of these fishes to dissociate the form destitute of cornua, and that with body-plates as well as a cephalic shield, from the other species (which agree in possessing cornua and in other matters very closely), than to leave them all in one group, each being equally designated *Cephalaspis*. It is quite possible that further research will render it desirable to consider what I have here called sub-genera as genera. Fragmentary remains indicating species belonging to the genus *Cephalaspis*, or only sufficient to point to the section *Osteostraci*, and not furnishing evidence of sub-generic detail, will be spoken of here as *Cephalaspis*.

Such remains occur in the Tilestones; in the Ledbury passage-beds we have *Hemicyclaspis*, and in the Cornstones of Herefordshire *Zenaspis*. *Eucephalaspis* is found in the Cornstones and the Scotch Lower Old Red.

1. Eucephalaspis Lyellii, *Agassiz*. Pl. VIII, fig. 1; Pl. XI, figs. 1 and 2.

Cephalaspis Lyellii, *Agassiz*. Pois. foss., vol. ii, p. 149, pl. 1, fig. 2, 1835.

Name.—Named after Sir Charles Lyell, Bart.

Stratigraphical Position.—Lower Old Red Sandstone (Scotch area).

[1] εὖ; and κεφαλάσπις, Cephalaspis.

[2] ἡμικύκλιος, semicircular; ἀσπίς, a shield.

[3] Ζεύς, Ζηνός, Jove; ἀσπίς, a shield.

Characters.—I must refer to the figures of the two specimens which are considered as belonging to this species for a notion of its characters. It was associated by Agassiz with the heads from the English Cornstones, which will here be spoken of as *Eucephalaspis Agassizii*, since they appear to differ in this point of structure, viz. that the orbits in the Scotch specimens are placed more posteriorly in the shield, and the cornua are less produced and less divergent than in the English heads. At the same time it must be confessed that there is very close agreement in the outline of the head-shield as exhibited in the best-preserved specimens. Neither of the Scotch specimens show the surface ornament, so that we cannot compare them in this regard. *C. Lyellii* and *C. Agassizii* were undoubtedly very closely allied, but the evidence does not justify their association under one specific name. The figures in the plates give all that is known on the matter.

General Remarks.—The specimen drawn by Mr. Dinkel in Pl. VIII, fig. 1, is the same which he figured more than thirty years ago for Prof. Agassiz. It has since then been worked out a little from the matrix, so as to exhibit the marginal series of scales. In the process the indications of the remarkable pectoral appendages drawn by Mr. Dinkel in Agassiz's plate, but not referred to in the letter-press, have been destroyed. Mr. Dinkel has, however, reintroduced them here, especially on the left side. A false notion of the structure of the body of *Cephalaspis* has been conveyed by the former drawings of this specimen and the copies in woodcuts illustrating popular treatises on geology. A jointed structure, as though the body were composed of a series of hard rings fitting into one another, has been in this way erroneously attributed to the fish (which mistake was by no means due to Prof. Agassiz, who knew and described the scales). The fact is that the scales of the body are of considerable thickness, and in the celebrated British Museum specimen drawn in Pl. VIII, fig. 1, their upper layers are entirely broken away, and only a flake of calcareous matter is left covering in their impressions, and thus producing the false jointed appearance. The deficiency in the specimen towards the caudal extremity marks the position whence the dorsal fin has been broken away. The other specimen, drawn in Pl. XI, fig. 1, which is referred to this species, is with, perhaps, the exception of Mr. Powrie's specimen drawn in Pl. X, fig. 1, and referred to *C. Powriei*, the most instructive and beautifully preserved remnant of these curious little old Sturgeons which has been found. It belongs to the Museum at Arbroath. The pectoral fins are well shown in the specimen, though I have to explain that my over-zealous friend Mr. Dinkel has given an appearance of a joint to the right-hand pectoral, which is not clearly seen in the fossil itself. The dorsal fin is also well shown, as is the caudal, but it is not so perfectly preserved in this as in another specimen (of another species probably) drawn on the same plate. The woodcut restoration (fig. 16) may help to elucidate the drawing of the fossil. The scales in this Arbroath specimen are unfortunately in the same broken condition as in the Glammis (Brit. Mus.) specimen, and no trace of the surface ornament is to be detected.

The Arbroath specimen has very fortunately been broken in such a way that a piece

of the body can be removed, and the view given in fig. 2, Pl. XI, is obtained. This demonstrates, firstly, a series of ventrally placed scales, which, though rather confused, covered in the ventral surface, and appear to have consisted of several rows. The great thickness of these scales, and indeed of those of the upper part also, is noticeable. The calcified exoskeleton in these fishes bore some resemblance to that of Lophobranchs, and, no doubt, formed a rather rigid and tough kind of armature. Secondly, the fractured piece of the Arbroath specimen exhibits the body in vertical section, and shows its very small calibre and triangular form.

Fig. 17.

Ideal vertical transverse section of the body of *Eucephalaspis*.

The number of rows in each series of scales is, no doubt, an important matter—possibly differing in species. Both specimens of *C. Lyellii* are unsatisfactory as regards this point, since the scales are fractured; but there appears to have been in front of the dorsal fin but one dorsal row of scales on each side the middle line, attached by their lower borders to the single series of great flanking or lateral scales: posteriorly to the fin the series became broken up into more numerous scales. The number of scales in a row and the relative length of head and body are important for specific distinction; and though it does not bear on the question of distinction between *C. Lyellii* and *C. Agassizii*, since the body of the latter is unknown, yet a very clear difference in this respect is exhibited between *C. Lyellii* and another Scotch species, *C. Powriei*.

The two specimens of *C. Lyellii* agree, as nearly as their rough condition will permit one to estimate, in having about twenty-five scales of the lateral series, placed prædorsally, *i. e.* which are in front of the anterior origin of the dorsal fin. In the British Museum specimen of *C. Lyellii* the length of the head is 3 inches, of the whole fish $8\frac{1}{4}$ inches, allowing for the tail, which gives a ratio of 1 to 2·4. In the Arbroath specimen the head is $2\frac{3}{4}$ inches in length, and the whole fish $7\frac{1}{4}$ inches, giving a ratio of 1 to 2·6. In *C. Powriei*, on the other hand, the ratio appears to be about 1 to 3·2. Allowance is made in these estimates for the parts which are broken.

The details of structure of the fins shown in the specimen at Arbroath do not allow of much being said, since they are not very clear. Small scales appear to extend along the fin-rays in both dorsal and caudal fin. It is, however, very important to notice that the

pectoral fin has quite a different structure, which is well seen in fig. 2, Pl. XI. There is no evidence of a separation of the calcareous matter into regular scales, but crescent-like areæ appear to be marked out by the greater thickness of this matter in some parts than in others; neither can any fin-rays be traced in these very curious organs.

2. Eucephalaspis Agassizii. Pl. IX, figs. 2, 3, 6.

Cephalaspis Lyellii, *Agassiz* (in part). Pois. foss., vol. ii, pl. 1 *b*, fig. 3, 1835.

Name.—Named after Prof. Louis Agassiz, the author of the 'Poissons fossiles.'

Stratigraphical Position.—The Cornstones of Herefordshire and Worcestershire.

Characters.—The woodcut, fig. 11, gives what is, I believe, an accurate indication of the form of the shield in this species. So many specimens of this are found that it is possible to get a more trustworthy idea of the form of the shield when uncrushed, and in all its parts, than it is in the case of any other *Cephalaspis*. Numerous as these specimens are, *only one* has come to hand showing clearly the form of the orbital region and the surface-markings. This has been used in drawing these parts in the woodcut,

Fig. 18 *a*. Fig. 18 *b*.

Ornament of *Eucephalaspis Agassizii*, magnified 7 diameters.

a, from the orbital region. *b*, from the posterior angle.

fig. 11, and was lent among many others by Dr. Grindrod, of Malvern. It is unnecessary to attempt any concise definition of the species in words when the woodcut figures express so much more clearly what is meant than a compressed sentence can be made to do. The relative position of the orbits in this species and in *C. Lyellii* may be seen on comparing the figures in Pl. VIII and Pl. IX.

General Remarks.—The greatest variation in form is exhibited by the abundant head-shields of this species which have been exhumed in the West of England—a variation due simply to pressure. Some shields are quite flat, and yet tolerably perfect; the outline in this case becomes very much widened, and the cornua are directed quite away from one another, instead of running backwards in nearly parallel directions; others are compressed laterally, but many are to be obtained which are regularly convex, and by their symmetry lead one to believe that they have not suffered any distortion. No specimens show the form and proportion of head-shield which is attributed to the following

species (*C. Powriei*), and hence we may consider the distinction, so far as it rests on the form of head-shield, a good one. Some small specimens, as that drawn in Pl. VIII, fig. 5, which probably belong to this species, show an outline rather like some small Scotch heads I have seen, one of which is drawn in Pl. XII, fig. 1. But the eyes are not so far forward in the Scotch specimens as in the English, and we may conclude that they belong to *C. Lyellii*, whilst the English ones belong to *C. Agassizii*. The Scotch member had 'a longer head' than the English representative, even among these fishes of the Devonian times.

No bodies of *C. Agassizii* appear to have been ever found attached to the heads, with two exceptions, one of which is obscurely drawn in Pl. VIII, fig. 5, whilst the other shows little beyond the fact of a scale-covered body. Both specimens are very small, and, indeed, may not belong to this species at all. They are from the Cornstones in the neighbourhood of Ludlow. Small specimens of scales, exhibiting a fine tubercular ornament like that of the head-shield of *C. Agassizii*, have been found, but give no evidence as to the form or relative proportions of the body. It is not a little remarkable that in the Cornstones of Herefordshire and in the slaty beds of Devonshire and Cornwall—which have lately (1868) been shown to contain *Cephalaspidæ*—the smallest traces of the body, well covered in by scales, as we know it to have been, should be so exceedingly rare as compared with the head-shields, which abound in the West of England, and are packed and pressed together in innumerable quantities in Cornwall. The relative size and weight of head and body, no doubt, favoured the preservation of the head-shields, which, like the Belemnite's guard, would sink, whilst the body would be broken off from the thus partially imbedded head. The large size and freedom from open sutures of the adult head-shields would also, no doubt, tend to their preservation, as compared with the smaller and therefore more easily scattered scales. A strange instance of the capricious imperfection of that very fragmentary document, the 'Geological Record,' is afforded in the absence of bodies to English Cephalaspids, and their more frequent occurrence in Scotch specimens.

3. Eucephalaspis Powriei. Pl. X, fig. 1, and Pl. IX, fig. 5.

Cephalaspis Lyellii, *Agassiz* (in part). Pois. foss., vol. ii, pl. 1, fig. 1, and pl. 1 *b*, fig. 1, 1835.

Name.—After Mr. Powrie, of Reswallie, Forfarshire, the discoverer of this and other Cephalaspids.

Stratigraphical Position.—Lower Old Red Sandstone of Forfarshire.

Characters.—The form of head-shield distinguishing this species is given in the diagram (woodcut, fig. 19). A form of curve which it is difficult to describe in words, but which might be expressed mathematically, distinguishes the contour of the shield of this form from those of the two preceding. The cornua have a different relative

proportion, and are more incurved than in *Eu. Lyellii* or *Eu. Agassizii*. There appear to be about thirty prædorsal scales in each series instead of twenty-five, and the scales are

Fig. 19.

Diagram outline of the head-shield of *Eucephalaspis Powriei*.

Fig. 20.

Ornament of the same from the cornu, magnified 7 diameters.

narrower in proportion to their length and of less thickness apparently than in *Eu. Lyellii*. The head measures $1\frac{3}{4}$ inch, the whole $5\frac{1}{2}$ inches in length, giving a ratio of 1 to 3·14, instead of 1 to 2·6. The ornament in this species is very finely tubercular. In Mr. Powrie's magnificent specimen, figured in Pl. XI, the ornament can be seen in parts with a lens, and may also be traced on many of the scales.

General Remarks.—The grand specimen of fig. 1, Pl. XI, was obtained by Mr. Powrie at Ley's Mill, near Arbroath. It has been most carefully developed, and shows the concave side of the head-shield, and the body twisted so as to bring the dorsal surface to the left side, as one looks at the specimen. Other head-shields, detached from the body, have come to hand, and one, belonging to Mr. Powrie, is figured in Pl. X, fig. 5. A similar specimen is in the collection of the Rev. Hugh Mitchell, of Craig, near Montrose. The specimen figured in pl. 1, fig. 1, of the 'Poissons fossiles,' and now in Sir Philip Egerton's collection, appears to belong to this species. It is most erroneously drawn in the figure referred to. The *concave* surface of half a head is presented with the half of the attached body, showing the position of the dorsal and caudal fins; but the dorsal series of scales is not preserved as drawn by Mr. Dinkel, the two sets of opposite sides being confused in a mass. The lateral series present the same appearance as those of Mr. Powrie's specimen; but I could not count as many as thirty prædorsal. The structure of the dorsal and caudal fins is not shown.

4. Eucephalaspis Pagei. Pl. X, figs. 3 and 4; Pl. XI, fig. 4.

Name.—After Mr. David Page, of Edinburgh, in accordance with the wish of Mr. Powrie, the discoverer of this form.

Stratigraphical Position.—Lower Old Red Sandstone of Forfarshire.

Characters.—The form of the head is very similar to that of *C. Powriei;* but it is difficult to be certain of its exact outline, since all the specimens obtained are much flattened. Some, however, show this character better than seen in the figured specimens, and from these the woodcut outline is drawn (fig. 21). The ornament is notably different

Fig. 21.

Diagram outline of head-shield of *Eucephalaspis Pagei.*

Fig. 22.

Ornament of the same, magnified 7 diameters.

from that of the several preceding species, for the tubercles are disposed in sets, consisting of a central large tubercle, surrounded irregularly, more or less, with smaller tubercles. The same character of marking is carried on to the scales. In one specimen (Pl. X, fig. 4) I could count about twenty prædorsal scales in a series; but the specimens of this species, though appearing very perfect at first sight, are so highly carbonized and crushed that it is impossible to ascertain the true arrangement of the scales. Some seem to indicate quite a different disposition of the series to that which I have described in *Eu. Lyellii* and *Eu. Powriei.* The dorsal and caudal fins are well seen in some specimens, but have not furnished any special characters; in no specimen of this species have the pectoral appendages yet been observed. The size of the majority of specimens is small. They may be young individuals; but their great number and the rare occurrence of large specimens with them, which seem to belong to another species, leads to the supposition that this is a *Cephalaspis* of small size when adult. At the same time it may prove to be a younger form of the succeeding species.

General Remarks.—Mr. Powrie discovered this form in some abundance in a remarkable bed of fine, dark, laminated shale and sandstone, which furnished also several Acanthodians,

and a few specimens of a larger *Cephalaspis*. The specimens are much carbonized and quite black, showing, however, the surface-markings and the scales in parts with a distinctness which varies in specimens and is liable to diminish by exposure after the exhumation.

There is a fact of interest with regard to the position assumed by the specimens in the rock. They are all very much flattened, but many have apparently also burst along the ventral line, so that the fossil presents the two rows of large flank scales spread out on each side of the dorsal series. This indicates great toughness in the tegumentary skeleton, and implies that the scales were held together by a very strong matrix of fibrous tissue, which was less firm along the ventral surface than in other parts. It has been suggested, as before noted (page 42), that the ventral part, if not the whole of the Cephalaspids, was covered and firmly connected through the aponeurotic scales with a skin containing small shagreen-like ossicles in parts. The continuity presented by the scales when crushed, as in the specimens of *C. Pagei*, favours this notion. In the *Heterostraci* it is clear, from the gland-pits, that there was a considerable development of the parts superficial to the calcified layers of the integument.

5. Eucephalaspis asper. Pl. X, fig. 5.

Name.—From the pointed spinets which exist on the scales and rim of the cephalic shield.

Characters and General Remarks.—The specimen figured, which is from a nodule in the Lower Old Red Sandstone of Perthshire, and another from the bed in Reswallie, Forfar, which furnished Mr. Powrie with *C. Pagei* and others of his valuable discoveries, present conoid or dentate spinets (fig. 23) situated on the marginal rim of the head-shield, being

Fig. 23.

Spinets from the margin of the shield of *Eucephalaspis asper*.

modified tubercles, and also on the scales, as seen in the figure. How far this structure is sufficient to characterise a species may very well be held to be doubtful, since such

denticular processes are very apt to get lost and obscured in these fossils, as, for example, those on the inner edge of the cornua of the common *Eucephalaspis Agassizii*. Perhaps this species may be merely a larger growth of *C. Pagei*, the spinets being preserved in the large specimens, but undeveloped or obscured in the smaller. Nevertheless, it is right to signalise this characteristic structure by a name. Further search in regard to this and other similarly dubious matters indicated in these pages is required, and the matter is best pressed on the attention of collectors and others by provisionally naming the supposed species. The horror with which the making of a species on small data is regarded by some naturalists appears to be a superstition which may lead to evil results, for the opposite proceeding of passing over all differences and indications of distinction among forms, unless of the most certain and obvious character, is far more injurious to the progress of knowledge. The use of a name, whether of genus, species, family, or what not, is merely to briefly draw the attention to a supposed speciality of structure separating the individuals, to which the name is applied, from others. There is nothing sacred in a name, and, if the progress of discovery render it desirable, old names can be changed or suppressed. As long as the data on which a species is named are fairly and fully stated, it can be no encumbrance to science, even though it should eventually prove to be not distinct from another form.

6. Hemicyclaspis Murchisoni. Pl. VIII, fig. 6; Pl. IX, fig. 1; Pl. XII, figs. 3 and 4.

Cephalaspis Murchisoni, *Egerton*. Quart. Journ. Geol. Soc., vol. xiii, p. 284, pl. ix, 1857.
— ornatus, *Id.* Ibid.

Name.—After Sir Roderick Impey Murchison, Bart.

Stratigraphical Position.—Tilestones and Auchenaspis-grits.

Characters.—The woodcut (fig. 24) presents the characteristic outline of the sub-genus and the ornament which characterises the species. The tubercles ornamenting the surface are arranged in distinct groups, marked out as polygonal areæ, in this species, more distinctly than in *C. Pagei*, some distance of intertubercular surface intervening between the contiguous groups.

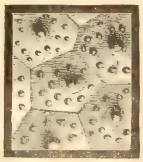
General Remarks.—Sir Philip Egerton (loc. cit.) described *C. Murchisoni* and *C. ornatus* originally as two distinct species, suggesting, however, that they might prove to be identical should specimens of *C. Murchisoni* showing the surface be discovered. I have received such a specimen from Dr. Grindrod, and do not doubt that the two specimens figured from the Tilestones near Ludlow and the two from the Ledbury Grits are the same species. A question was also raised by Sir Philip as to whether *C. Murchisoni* might not belong to his genus *Auchenaspis*, being thus the anterior portion of a shield divided into head- and neck-plates. The presence of a groove running parallel to the edge of the semicircular shield seems to me to oppose this notion, for a similar groove runs

along the posterior margin of the shield of *Eucephalaspis*, and also along the posterior margin of the *posterior* or neck-plate of *Auchenaspis*, whilst there is no trace of such a

Fig. 24.

Diagram outline of the head-shield of *Hemicyclaspis Murchisoni*.

Fig. 25.



Ornament of the same, magnified 7 diameters.

grooving along the posterior margin of the anterior piece of the shield in either *Auchenaspis* or *Didymaspis*.

I was told by Dr. Anton Fritsch, of Prague, that he had obtained when in England a specimen of this species showing parts of the body, but I have no details as to its state of preservation, and am not certain that this was the species obtained. Fragments of this species are not uncommon in the micaceous sandstone at Ledbury, which has furnished a large species of *Auchenaspis*. There are only two specimens in collections, which come from the finer argillaceous Tilestones, where it occurs with another *Cephalaspis* and with the small *Auchenaspis* described by Sir P. Egerton as *Au. Salteri*. As might be expected, the ornament is rarely preserved in the specimens from the 'Grits,' whilst the two from the Ludlow Tilestones show it admirably.

7. Zenaspis Salweyi. Pl. XII, figs. 2, 5, 6; Pl. VIII, figs. 2, 3, 4.

Cephalaspis Salweyi, *Egerton*. Quart. Journ. Geol. Soc., vol. xiii, p. 283, pl. x, 1857.
— asterolepis, *Harley*. Ibid., p. 503, 1859.
— — *Lankester*. Brit. Assoc. Reports, 1864.

Name.—Named in honour of Mr. Humphrey Salwey, of Ludlow.

Stratigraphical Position.—Cornstones, probably in a special horizon, with *Scaphaspis rectus* and *Pteraspis Crouchii*.

Characters (see the woodcut, fig. 26).—The large size of the tubercles, which are

Fig. 26.

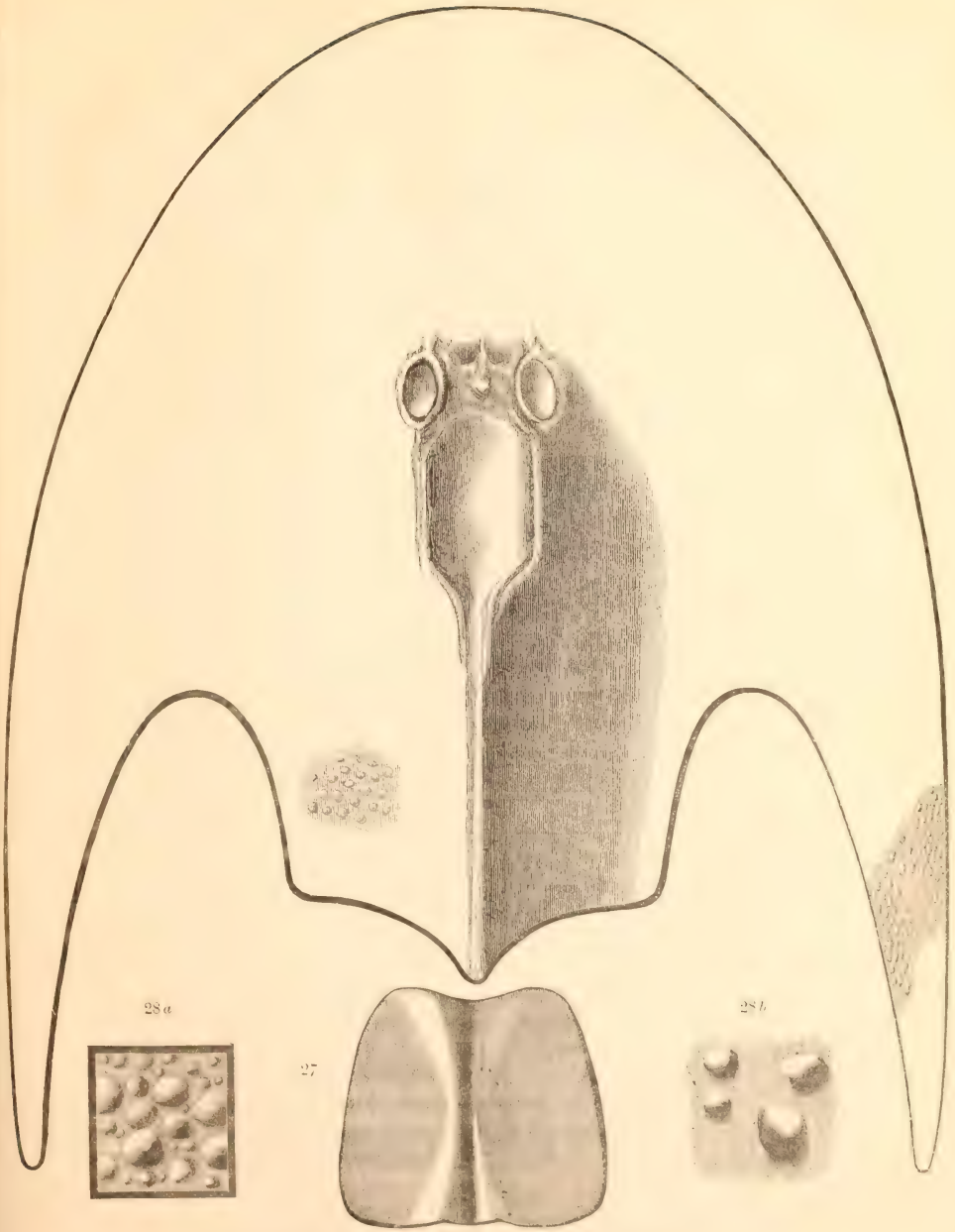


Fig. 26.—Diagram outline of the head-shield of *Zenaspis Salweyi*, natural size.
„ 27.—Dorsal scute of the same.
„ 28*a*.—Ornament from near the front of the shield, magnified 7 diameters.
„ 28*b*.—Ornament from near the middle of the shield, magnified 7 diameters.

largest in the large shields, as may be seen by comparing Pl. XII, figs. 2 and 6, and Pl. VIII, fig. 4, and their less frequency, distinguish the ornament of this species from that of *Eucephalaspis Agassizii*, specimens of nearly equal size being compared. The thickness of the substance of the shield is relatively great, and it has a bright polished surface. The cornua are long, subcylindrical, and solid, differing in this, as does the shield-substance in thickness, from *Eucephalaspis Agassizii;* the tubercles on the surface are oblong and closely packed. The ends of these cornua are not unfrequently found detached, having survived the destruction of the rest of the shield, from which they appear to have been readily broken. The postorbital valley is shorter and broader relatively in this species than in other Cephalaspids. Sir Philip Egerton attached importance to the great breadth between the eyes, but the size of the individual and variations in pressure are liable to affect this character. A greater interspace between the orbits is, no doubt, present than between those of *Eu. Agassizii*, if orbits of equal size or nearly equal size be compared. But the real point is that the orbits are *much smaller* in this species, relatively to the size of the whole shield, than in *Eucephalaspis*.

General Remarks.—After some hesitation I have decided to associate *C. Salweyi* and *C. asterolepis* as one species, not being able, on careful examination, to find any character which should separate the large specimen described by Dr. Harley from Sir Philip Egerton's original *C. Salweyi*. A magnificent specimen has been kindly lent to me by Mr. Lee, of Caerleon, from which the outline woodcut has been in great measure drawn; two cornua, belonging to Dr. MacCullough, and found in the same quarry at Abergavenny, furnishing the evidence of these parts which are wanting in Mr. Lee's specimen. This specimen came to hand after my plates had been completed; it has been photographed and published in a recent volume of the 'Proceedings of the Woolhope Nat. Field Club.' Another specimen, which is better than either of those drawn in my plate, has been recently obtained for the British Museum. It is very similar to Mr. Salwey's specimen drawn in Pl. XII, fig. 6, but it has the long cylindrical cornua attached to the angles of the shield, which are wanting in this specimen. The ornament is best shown on these two shields, the irregular 'splashed' character of the tubercular markings being well seen. In parts they assume a much more regular character, each tubercle being hemispherical, and all nearly of equal size (Pl. VIII, fig. 4). Bits showing this character of marking from shields of twice the size of that drawn in Pl. XII, fig. 6, and therefore with much larger tubercles, are not uncommon, and have been regarded distinctively as *C. asterolepis*, but I cannot believe that the difference is anything but one of size. None of the large specimens usually referred to *C. asterolepis* show the *tubercles* of the surface of the shield in such a way that they can be compared with those of the smaller specimen drawn in fig. 6, Pl. XII. On such specimens a few of the larger tubercles are left here and there adhering. I do not doubt that if we have had the ornament properly shown, we should find oval, circular, and irregular tubercles of *various sizes* on parts of the shield, as in typical *C. Salweyi*. I say typical *C. Salweyi*, for though Pl. XII, fig. 5, is the figured type

specimen, and shows very little of the surface, fig. 6, Pl. XII, which shows so much more, may be taken as more fairly representing it, and was so regarded by Dr. Harley.

The character of the tubercles varies on different parts of the same shield in this species very greatly; in some parts there are fewer tubercles than others, and they are round and of equal size; in other parts they are crowded so as to leave no intertubercular surface, and are small and large, oval and round, and irregular. This latter arrangement is seen near the margin more particularly, which, as we saw in *Scaphaspis* (Pl. I, fig. 4 *a*), is subject to crowding and irregularity.

The remarkable scutes drawn in Pl. VIII, figs. 2 and 3, present a very large form of ornament, which is regular in size and hemispherical, as seen in Pl. VIII, fig. 4. They occurred in association with the specimen drawn in fig. 2, Pl. XII, and, no doubt, belong to the same species of fish, the character of their substance and ornament leaving little room for doubt on this point. It is the occurrence of these very remarkable scutes which has induced me to form the subgenus *Zenaspis*, since they indicate an arrangement of the armature of the body quite different from that of *C. Lyellii*. The scutes are symmetrical in form, and were therefore probably placed in the median line, probably on the dorsal surface. In Pl. XIII, figs. 17 and 18, somewhat similar and smaller scutes are drawn. These additional scutes, which thus characterise the subgenus *Zenaspis*, apparently belonged to bigger individuals than that drawn in Pl. XII, fig. 6, for which their ornament is too large. All fragments of such additional plates as these should be carefully looked after by collectors, since the specimens figured, and others less definite which have been submitted to me, indicate a considerable development of such plates, in the place of the scales of *Eucephalaspis*, and may possibly require a generic in place of a subgeneric recognition. The flank-scales of individuals as large as Mr. Lee's specimen must have been of considerable strength and size, if they retained merely the relative proportions seen in *Eucephalaspis*; but if, as is not impossible, they united in parts to form still larger plates, we may expect assuredly that they should be detected in the Cornstones.

The 'rims' of the cephalic shield of this species are sometimes found alone, being solid and of a shape to resist destruction after the breaking away of the expanded dome which carries the orbits, &c., as may be observed in other species (see Pl. IX, fig. 4, and Pl. XIII, fig. 19).

8. Cephalaspis Lightbodii. Pl. XIII, fig. 19.

Name.—After Mr. Lightbody, of Ludlow.

Stratigraphical Position.—Tilestones, near Ludlow; from the same fine argillaceous bed which furnishes *Hemicyclaspis Murchisoni* and *Auchenaspis Salteri*.

Characters.—The peculiar form of ornament definitely characterises this species. On

the margin or rim of the shield are very densely set conical or pyramidal tubercles of the size of a pin's head and larger. The apices of some of these tubercles are curved so as to form little hooks. The upper surface of the shield, to judge from a piece seen at the lower portion of the figure, which may, however, belong to another plate, was ornamented with equally close-set tubercles, so closely set and of such irregular angular form that their impress in the matrix has the appearance of a network. But what is chiefly remarkable is the presence of a set of grooves, independent of the tubercles, winding about amongst them in such a way as to mark out irregular areas of a quarter of an inch or less across, giving an appearance which is seen on some Reptilian scutes, and which is but feebly rendered in Mr. Dinkel's drawing in Pl. XIII.

General Remarks.—This species was pointed out to me some time ago by my friend Mr. Lightbody, who has a few fragments besides the rim here figured. I have great pleasure in naming this very interesting form after one who has done so much in the investigation of these matters, and has given me so much assistance in my task.

It is impossible to say what subgenus this *Cephalaspis* would fit into, or whether it would require a new one. Its large size and very definite peculiar ornamentation render it probable that we shall soon hear of it again. Extending inwards from the rim are seen in the specimen the 'lateral floors' of the shield. The tubercles on their surface are much smaller than those on the rim itself.

Genus 2.—Auchenaspis, *Egerton.* Quart. Journ. Geol. Soc., vol. xiii, p. 286, 1857.

Derivation.—ἀυχήν, the neck; ἀσπίς, a shield.

Characters.—Scutum in duas partes divisum, anteriorem semicircularem in quâ sunt oculi positi, cornibus lateralibus magnis instructam majorem, posteriorem oblongam minorem.

α. Auchenaspis.—Cornibus lateralibus modestis.

β. Eukeraspis.[1]—Cornibus lateralibus longissimis, cellulis marginalibus magnis.

1. Auchenaspis Salteri, *Egerton.* Pl. XIII, figs. 7, 8.

Auchenaspis Salteri, *Egerton.* Quart. Journ. Geol. Soc., vol. xiii, pl. ix, 1857.

Name.—After the late Mr. J. W. Salter, of the Geological Survey.

[1] εὖ, intensitive; κέρας, cornu; ἀσπίς, shield.

Stratigraphical Position.—The Tilestones (the fine-textured deposit occurring near Ludlow).

Fig. 30.

Fig. 29.

Diagram outlines of head-shield of *Auchenaspis Salteri* and *Au. Egertoni.*

Characters.—This species is distinguished by its small size and by the small divergence of its lateral cornua. The surface-ornament is not known.

General Remarks.—I have had but few specimens of this species to examine. I think that the uniformly small size of the specimens from Ludlow, whence Sir Philip Egerton's type was obtained, as also the difference in the apparent curvature of the anterior portion of the shield and its less divergent cornua, justify the separation of this form from that which occurs in some abundance in the micaceous grits of the Ledbury Passage-beds.

2. Auchenaspis Egertoni. Pl. XIII, figs. 3, 4, 5.

Name.—After Sir Philip de Malpas Grey Egerton, Bart., the author of the genus.

Stratigraphical Position.—The Ledbury Passage-beds, or 'Auchenaspis-grits.'

Characters.—Compare the woodcut outlines of the two species, figs. 29 and 30. The three specimens of this species drawn in Pl. XIII are variously imbedded in the matrix, one showing more of the cornua than another. The specimen which is intended to be represented in fig. 3 is the most characteristic, but has not been well drawn on the plate. The cornua are largely developed and diverge from the posterior or neck-plate: the shield has more than twice the vertical diameter of the preceding species. The surface shows in some specimens tubercular ornament of relatively very large size.

General Remarks.—This species used to be almost abundant at Ledbury in the grey micaceous grits which were exposed in the railway-cutting on that side of the Malvern and Hereford Railway-tunnel. Mr. Brookes, well known to many as a clever collector and a working-man of great intelligence, sometimes obtained four or five of these heads on one hand-specimen of the stone; they occurred associated with fragmentary remains of *Hemicyclaspis Murchisoni.*

3. Eukeraspis pustuliferus, *Agassiz.* Pl. XIII, figs. 9—14.

Schlerodus pustuliferus, *Agass.* Sil. Syst., pl. iv, figs. 27, &c.; Siluria, pl. xxxv, figs. 9—12.

Plectrodus mirabilis, *Agass.* Sil. Syst., pl. iv, figs. 14, &c.; Siluria, pl. xxxv, figs. 3—8.

Name.—*Pustuliferus,* bearing pustules, on account of its fine tubercular ornament.

Stratigraphical Position.—The Downton Sandstone of Ludford Lane, near Ludlow.

Characters.—Posterior portion of the shield not known; cornua twice as long as the central or vertical diameter of the anterior portion of which they are processes; a series of six cavities (cellulæ marginales), woodcut, fig. 31, *c. m.*, on either side excavated in the

Fig. 31.

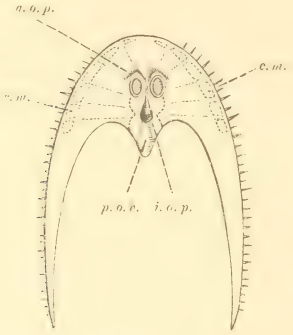


Diagram outline of head-shield of *Eukeraspis pustuliferus.*
a. o. p. orbital prominence; *c. m.* marginal cavities; *p. o. v.* post-orbital valley; *i. o. p.* interorbital prominence.

Fig. 32.

Ornament of the same, magnified 7 diameters.

substance of the shield; a similar pair of cavities (appearing like orbits in fig. 13, Pl. XIII) are placed posteriorly to the true orbits and on either side of a very marked prominence (*i. o. p.* in the woodcut), like the interorbital prominence of *Cephalaspis* (seen in Pl. XIII, fig. 10). The true orbits are deeply sunk, and are seen in figs. 13 and 14; the right orbit, which is preserved in the specimen drawn in fig. 13, and lies anteriorly to and somewhat to the left of the right hand of the two oblong cavities, there drawn, is not clearly seen. The antorbital prominences (*a. o. p.* in the woodcut) are very marked and prominent in this form; as to the antorbital fossæ I am uncertain. The whole surface is covered by a very fine densely set series of circular tubercles of very small size and great regularity, extending on to every prominence and furrow of the shield. The

cellular cavities of the margin and of the central part of the shield were only indicated superficially by slight undulations of the tuberculated test. The *outer* margin of the shield, especially of the cornua, contrary to what is seen in *Cephalaspis*, where the *inner* border of the cornua is denticulate, is furnished with irregularly tooth-like processes of various length.

General Remarks.—The remains of this beautiful and well-marked little Cephalaspid were described in the 'Silurian System,' and the earlier editions of 'Siluria,' from detached specimens of the cornua, as *toothed jaws of small* ganoid fishes, *Pt.* (*Sclerodus*) *pustuliferus* and *mirabilis*. In the last edition Sir Roderick remarks that Dr. John Harley (formerly of Ludlow) had suggested the true nature of these supposed fish-jaws. (See description of Pl. XXXV in 'Siluria,' 1867.) At page 241 of the same edition it is stated that Mr. Salter was inclined to regard these cornua as the jaws of Cephalaspis or Pteraspis. The most important feature about *Eukeraspis* appears to me to be the existence of the remarkable cavities between the two laminæ of the shield-test, but unfortunately it is exceedingly difficult to ascertain definitely their structure and relations, on account of the rarity of specimens of the fish, and especially of specimens well preserved. Were it possible to describe these structures with accuracy, their peculiarity, though paralleled by feebly developed marginal cavities in *Cephalaspis*, would, I think, justify the erection of *Eukeraspis* into a totally distinct genus. The small vertical breadth of the shield, and the outline of its posterior border, as seen in fig. 13, Pl. XIII, renders it improbable that we have in these beautiful little specimens a complete cephalic shield comparable to that of *Eucephalaspis*, and leads one to suppose that an additional plate such as is presented by *Auchenaspis* was attached along this border. This is a question which inquiry with the hammer may soon decide; provisionally, *Eukeraspis* may remain as a subgenus of *Auchenaspis*.

The only specimens yet obtained of this form are from the Downton Sandstone near Ludlow.

Genus 3.—Didymaspis, *Lankester*.

Didymaspis, *Lankester*. Geol. Mag., vol. iv, p. 152, 1867.

Derivation.—δίδυμος, twin; ἀσπίς, a shield.

Characters.—Scutum in duas partes subæquales divisum, anteriorem semicircularem in quâ oculi sunt positi, sine cornibus divergentibus, posteriorem oblongam.

1. Didymaspis Grindrodi, *Lankester*. Pl. XIII, figs. 1, 2.

Didymaspis Grindrodi, *Lankester*. Geol. Mag., vol. iv, p. 152, pl. viii, 1867.

Name.—In honour of Dr. Grindrod, of Malvern.

Stratigraphical Position.—In Red Sandstone, immediately above the 'Auchenaspis Grits' of Ledbury.

Characters and General Remarks.—See woodcut, fig. 33. The fossil is in two

Fig. 33.

Diagram outline of the head-shield of *Didymaspis Grindrodi*.

pieces, one showing the convex cast (Pl. XIII, fig. 2), the other concave surface (Pl. XIII, fig. 1), of the cephalic shield. This shield is of an oval form, about an inch in length and a little less in breadth. Anteriorly it is divided by a well-marked junction-line into two portions—an anterior semicircular piece and a posterior larger and somewhat square piece. The anterior portion exhibits two distinct oval orbits, placed close together at its centre. Radiating channels mark the inner surface of this portion of the scute, recalling the similar 'channeling' in *Cephalaspis* (also seen in *Auchenaspis*, being the structure which gave rise to the supposition of a fibrous bony skull in Agassiz's description of *Cephalaspis*). The line of junction between the two plates describes a double curve; the two produced angles of the semicircular plate embracing the posterior plate, but not diverging from it, whilst in the median line the anterior piece is produced into the posterior to a small extent: in this way the double curvature of the margins is effected. Posteriorly the posterior plate becomes contracted, and its margins tend towards describing a dome-like outline when it is abruptly truncated, and the truncated margin thickened and inflected. A thickened ridge passes anteriorly along the median line. No radiating channels mark its inner surface. Flake-like fragments from the inner substance of the scute, soaked in Canada balsam and examined beneath the microscope, show large bone-lacunæ very densely packed, arranged at right angles in the different lamellæ of the bony material, so as to produce the appearance of cross-hatching.

The small specimen figured, which is from Dr. Grindrod's great collection, is the only relic of this form which we at present possess.

A. In Pl. XIII one or two fragments of scales are figured which may possibly be connected with Cephalaspids, or with the bearers of those ichthyodorulites which not unfrequently occur in the Cornstones of Herefordshire and subjacent beds, and have been designated *Onchus*.

I would particularly draw attention to the beautiful fragments which I have termed

Kallostrakon podura, on account of the resemblance of their ornament to the well-known microscopic markings of the scales of the insect *Podura*. The microscopic structure of a portion of the scale drawn in fig. 21, Pl. XIII, is given in fig. 6, Pl. XIV, and is well worth attention, on account of its very peculiar nature.

The numerous indeterminable fragments of fish remains, together with the *Onchus* species, which occur in Siluro-Devonian beds require careful collation and study; they appear to indicate the presence of other *groups* of fish in company with the *Cephalaspida* described in these pages.

B. Since the plates of this Monograph were completed, and the first part issued, a great discovery has been made, or rather a rediscovery relating to its subject-matter. *Cephalaspidæ* have been found in Devonshire and Cornwall, in beds assigned to the Lower Devonian series. Mr. Peach long since (in 1847) described the remains in question as fish, and latterly, from specimens belonging to Mr. Pengelly, the Cephalaspidian nature of the remains, which had in the interim been considered as Sponges, has been decided by the Rev. W. S. Symonds, by Prof. Huxley, Mr. Salter, and myself. Innumerable remains of the shields of a *Scaphaspis*, more than a foot long, fragments of *Cephalaspis*, numerous spines, and other indeterminable fragments, besides the splendid scale and spine assigned by Mr. Pengelly respectively to *Phyllolepis* and *Ctenacanthus*, are the fish remains of these beds. Mr. Pengelly, Mr. Peach, and the Royal Geological Society of Cornwall, have kindly lent me their specimens for further examination.

C. Before leaving the subject, and now that the various forms and remains of the Cephalaspidian Fishes known have been described and figured to the reader, I should wish to revert to the question of their zoological position discussed in the first pages of this Monograph. Since they are the earliest remains of Fish presented to us by the geological record, we should naturally expect them to exhibit a difference of organization as compared with living fishes, leading us downwards to some invertebrate group. But it cannot be too strongly asserted that these Fishes are, as far as can be seen, by no means of a low type, and that, so far from showing any real affinities with lower types of animal life, such as the fancied relationship with Crustacea or Cephalopoda, they disclose, upon careful examination, points of structure, such as the double olfactory cavities and the pectoral appendages, which place them very far above some living Vertebrata (Lampreys) classed as Fishes. At the same time there is nothing in the remains known to us which will indicate even approximately their affinities to any one of the large groups recognised in the classification of Amphirhine Fishes. So great is the variation in the distribution of calcareous matter in the exo- and endo-skeletons of Fishes that in these, as in so many other fossil members of the class, no evidence is given by which we can judge of the condition of the important respiratory, circulatory, and digestive organs which accompanied the skeleton. The calcified skeleton in *Cephalaspidæ*, apparently, was entirely confined to the aponeurotic or 'splint-system' of Mr. Parker; and whilst the endo-skeleton was cartilaginous, it may have been of high or low development. Apparently, too, like the Lophobranchs and

Plectognaths, the *Cephalaspidæ* may have had the aponeurotic part of their exo-skeleton separated wholly or in parts from the upper layers of the *cutis vera*, which may or may not have existed in a calcified condition. The series of scales or bones along the body of *Cephalaspis*—so strongly recalling the cinctures of *Callichthys* (which has a complete endo-skeleton)—are, probably, morphologically of the same nature as those structures, but anteriorly I have not been able to detect any modification of the flanking 'scales' in *Cephalaspis* in the form of clavicular bones. The very peculiar pectoral fins of *Cephalaspis* are unlike those of Ganoids or Teleosteans; their broad membranous character is most nearly represented in Sharks; but just as the character of their skeleton does not render it *impossible* that they were Elasmobranchiate, nor point distinctively to either Ganoids, Siluroids, Lophobranchs, or Plectognaths as their modern congeners, so do the fins fail to give any decisive indication, for have we not classed among Ganoids *Holoptychius*, *Polypterus*, *Amia*, and *Sturgeon?*

It is best, then, to let the group *Cephalaspidæ* stand alone,[1] since they present a combination of characters which is not inconsistent with any one of the recent types of internal organization presented by Fish, whilst agreeing with no living type of skeleton entirely. When their position in time is considered, it becomes very probable that they possessed an internal skeleton and viscera of more *general* character than any of the higher living Fishes now present to us, which would justify their distinct position. The solid character of the aponeurotic skeleton in the body of *Cephalaspis* and its vertical segmentation, together with the non-calcification or the separation of the more superficial parts of the integument and of the cartilaginous endo-skeleton, may be considered as indicating a generalised condition of structure, in which the splint-skeleton was so far dominant as to take on that self-repetition which is, in other cases, known to us as vertebral segmentation.

The Heterostraci are associated at present with the Osteostraci because they are found in the same beds, because they have, like *Cephalaspis*, a large head-shield, and because there is nothing else with which to associate them. There is at present no evidence that the body and fins of *Pteraspis* and its allies were like those of *Cephalaspis*, and the shields are not so closely similar in plan, much less in histological structure, as to warrant any inference of similarity in other parts. Especially it is to be noted that, unless the apertures considered as orbits in *Pteraspis* represent the antorbital fossæ or olfactory organ of *Cephalaspis*, there is a total absence of such fossæ in the Pteraspidian shield, whilst the alternative gives the absence of orbits, either of which is an important difference.

The discovery of the bodies of *Heterostraci* will be a most welcome addition to science, and for this we wait.

[1] Professor Huxley's last suggestion on this matter ('Academy,' No. 2, p. 42) is that the *Cephalaspidæ* possibly connect the Monorhina (Lampreys) with the Sturgeons among the Amphirhine; but why should their exo-skeleton have so much importance attached to it as to indicate a leaning towards Ganoids rather than Sharks? Professor Huxley even speaks of the *Cephalaspidæ* as Ganoids simply, which seems to be taking too much on 'faith,' as regards their unknown viscera.

PLATE VI.

Fig.

1. *Pteraspis rostratus*, Ag. A very fine specimen; with the surface markings (striæ and pits) well shown. Cradley. Dr. Grindrod.

2. A similar specimen, showing more of the posterior portion of the shield. Cradley Dr. Grindrod.

3. A natural cast of the surface of part of the shield of *Pt. rostratus*, showing the disposition of the markings round the orbit and on the cornu. Notice in this and in fig. 1 the aperture (*a*) in the cornu, giving the appearance of a detached projecting angle to part of the cornu. Author's cabinet.

4. A disc of *Pt. Crouchii*, showing clearly the characteristic form and the deep incision posteriorly for the spine.

5. *Cyathaspis Symondsi*. Cornstones, Herefordshire. In the Museum of the Geological Survey (Jermyn Street).

6. A specimen of *Pt. rostratus*, showing the superficial markings of the posterior portion of the shield. In the collection of Mr. James R. Gregory.

7, 8. Rostra of *Pteraspis Crouchii*. From the neighbourhood of Ludlow.

9. A fragment of *Pt. rostratus*, consisting of the 'orbital portion.'

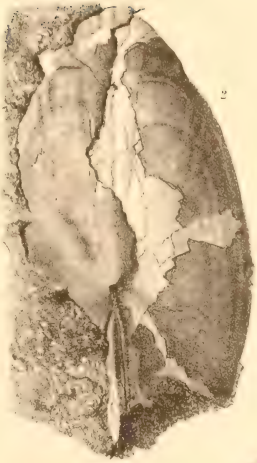


PLATE VII.

FIG.

1. A portion of the test of *Scaphaspis Lloydii;* considerably enlarged, to show the form of the surface ridges and the coarser structure of the lower layers of the shield. The piece is from near the centre of the shield. Observe the flatness of the ridges.
2. A similar piece from the shield of *Scaphaspis rectus*, drawn to the same scale (the lower nacreous and cancellated layers not being given). The ridges are of smaller size.
3. A similar piece from the shield of *Pteraspis rostratus*. The ridges are much narrower, and are rounded. Drawn to the same scale.
4. A similar piece from the shield of *Pteraspis Crouchii*. The ridges are nearly as broad as in *Sc. Lloydii*, and quite as flat. Drawn to the same scale.
5. A portion of the shield of *Pt. rostratus*, taken nearer to the margin, and including three of the 'pits' or mucous-gland-sites. Same scale.

5*a*. A fragment, showing the cancellated layer or polygonal cavities. Same scale.

6. A portion of the shield of *Sc. Lloydii*, from very close to its margin. The ridges become exceedingly narrow, but maintain their relative proportion as compared with ridges from similar parts in *Pt. rostratus*. Compare this with fig. 5, and fig. 1 with fig. 3.
7. The microscopic structure of the shield of *Pt. rostratus*. A section has been taken traversing the ridges, four of which are seen in section. The dark matter above these is matrix. After Professor Huxley.
8. Restoration of the cephalic shield of *Pteraspis Crouchii*, Salter.
9. „ „ *Pteraspis rostratus*, Agassiz.

These drawings and those in Pl. VI should be examined with a magnifying glass. The striations have been very carefully rendered by Mr. Fielding, but it was not possible for him to draw them actually as closely packed as they are in reality.

10. The microscopic structure of *Pteraspis rostratus*. A section has in this case been taken parallel to the ridges. The vascular tufts and their connections with the polygonal cavities are seen. Original.
11. Under surface of the rostrum of *Pteraspis Crouchii*. Restored.
12. „ „ *Pteraspis rostratus*. Restored.
13. Ideal longitudinal section through the shield of *Pteraspis rostratus*.
14. „ „ *Pteraspis Crouchii*.
15. „ „ *Scaphaspis Lloydii*.
16. Ideal transverse section passing just in front of the insertion of the spine in *Pteraspis Crouchii*.
17. „ „ more posteriorly.
19. „ „ more anteriorly.
18. Transverse section of *Scaphaspis Lloydii*.

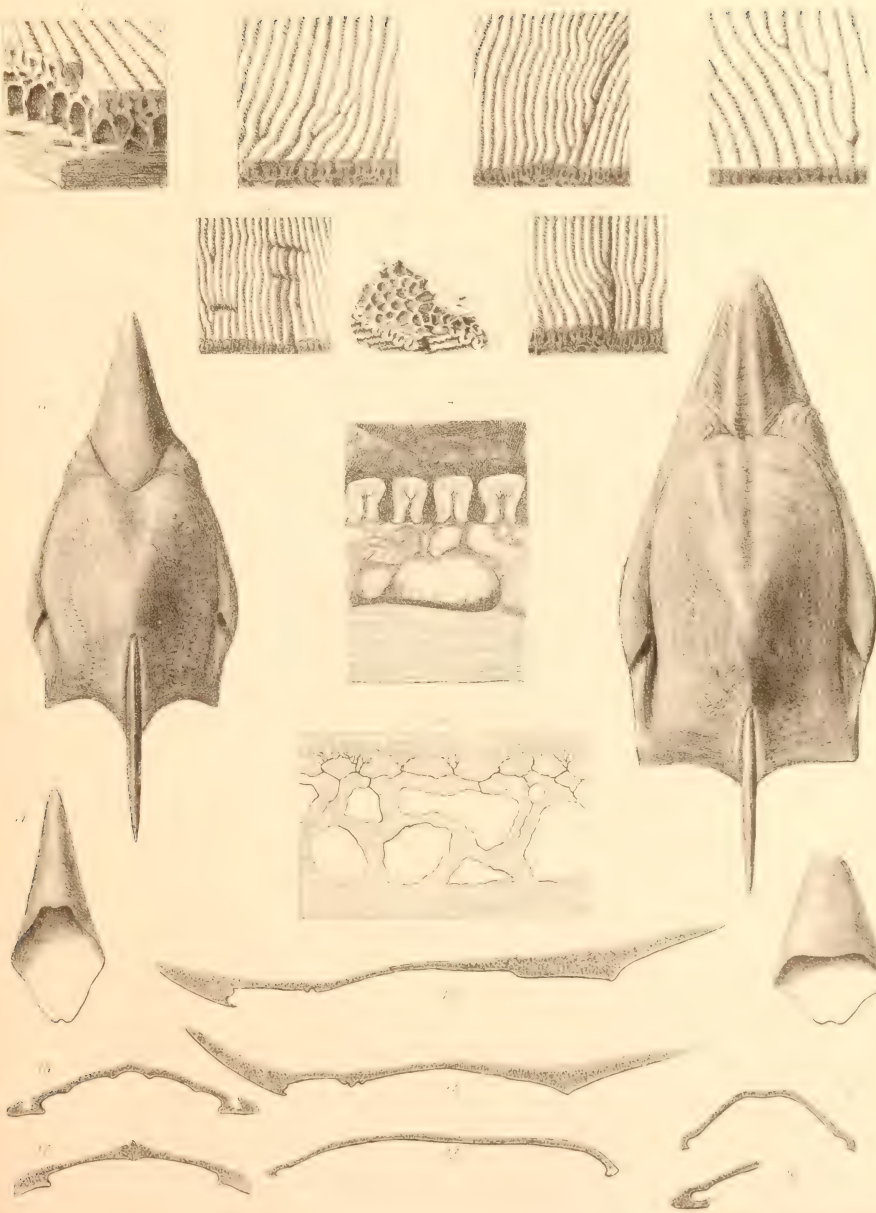


PLATE VIII.

FIG.

1. *Eucephalaspis* (*Cephalaspis*) *Lyellii;* the specimen figured by Agassiz, 'Poissons fossiles,' pl. i, fig. 1, 1835, now in the British Museum. The artist has introduced the indications of pectoral appendages which were broken away in exposing the series of marginal scales. Glammis, Perthshire. Compare the direction of the scales in this and in Pl. XI, fig. 1.

2. A specimen of a scute, not forming part of the cephalic shield, and proved by its ornamentation and occurrence to belong to *Zenaspis* (*Cephalaspis*) *Salweyi* (= *asterolepis*). Cornstones, Herefordshire. In the Museum of the Geological Survey.

3. Another, similar scute. Cornstones, Herefordshire. In the Museum of the Geological Survey.

4. A somewhat similar fragment of doubtful character, but showing well the ornamentation as an intaglio. Cornstones, Herefordshire.

5. A small *Cephalaspis* from Herefordshire, showing the body in a rather fragmentary condition, which the artist has failed to render. In the collection of Mr. Morton, of Liverpool.

6. *Hemicyclaspis* (*Cephalaspis*) *Murchisoni:* a fine specimen of the head-shield from the Passage-beds of Ledbury, Herefordshire. In the collection of Dr. Grindrod.

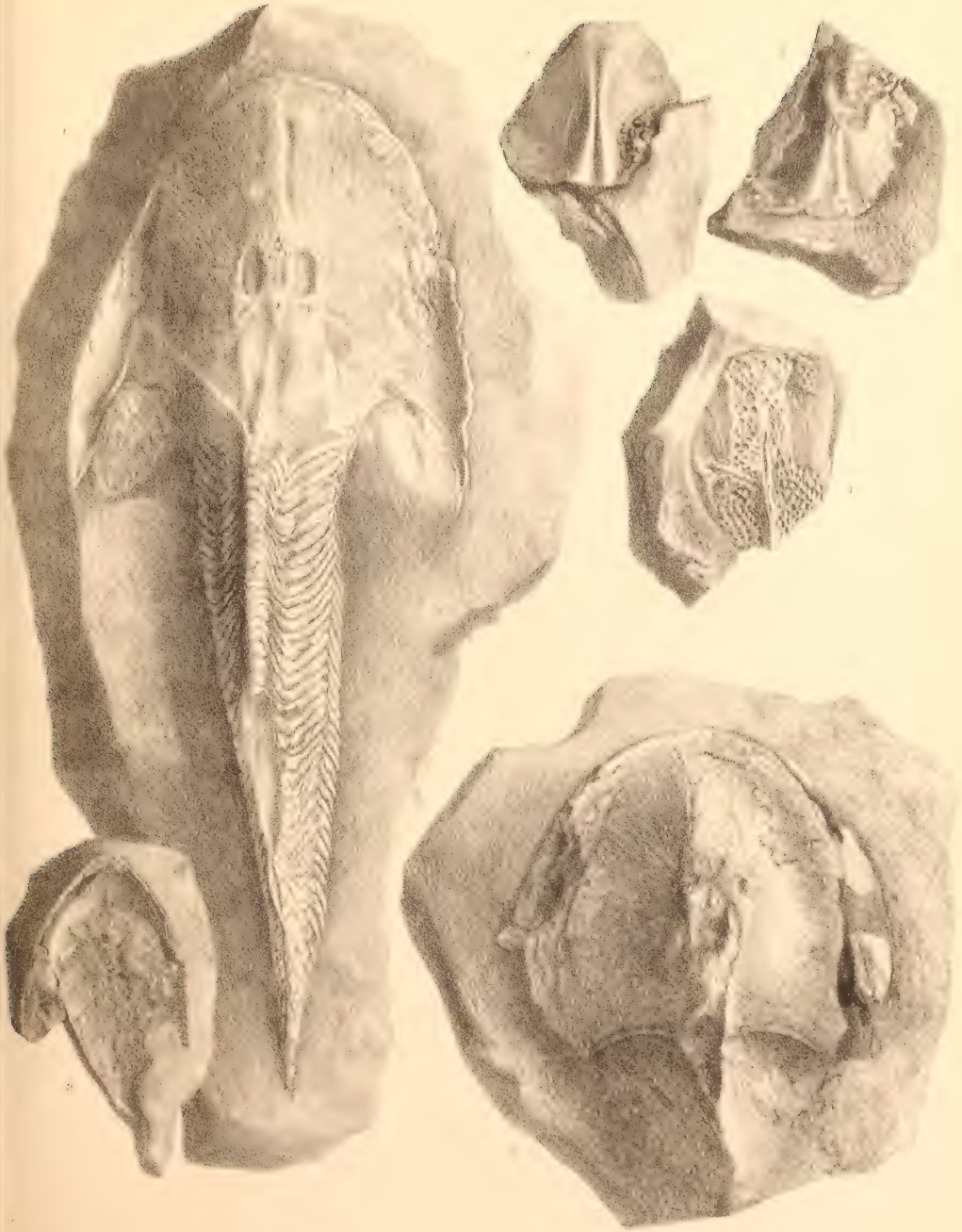


PLATE IX.

FIG.

1. Head-shield of *Hemicyclaspis* (*Cephalaspis*) *Murchisoni*, showing well its posterior margin and the angle of the shield on the left side. Passage-beds, Ledbury. Dr. Grindrod. (See also Pl. I, fig. 6, and Pl. XII, figs. 3 and 4.)

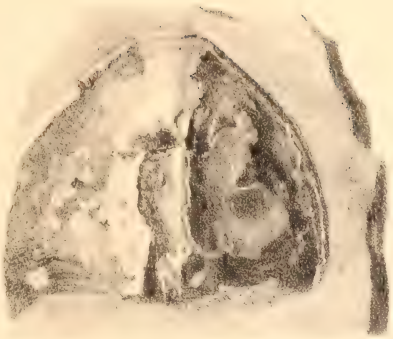
2. *Eucephalaspis* (*Cephalaspis*) *Agassizii;* a head-shield from the Cornstones of Herefordshire, which has not been crushed. The part of the cornu which is seen is not its upper, but its lower wall. Mr. Lightbody, of Ludlow.

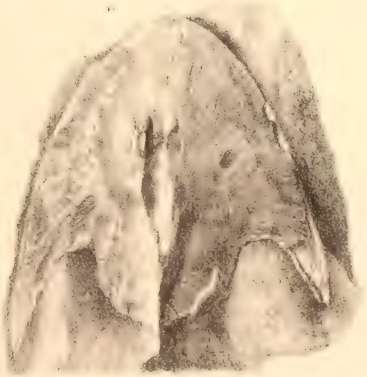
3. *Eu. Agassizii;* a head-shield, exhibiting a more complete outline than fig. 2, but a little crushed, whence the more ovoid and smooth contour which it presents. Cornstones, Cradley. Dr. Grindrod.

4. A rim of a Cephalaspidian shield, perhaps *Hemicyclaspis Murchisoni*. Passage-beds of Ledbury. Dr. Grindrod.

5. A large head-shield of *Eucephalaspis Powriei*. The very great breadth of the shield is due to the flattening by pressure to which the fossil has been exposed; making allowance for this, the form of the cornua and the relative size and position of parts of the shield may be contrasted with those in the neighbouring figures. Mr. Powrie.

6. *Eucephalaspis Agassizii;* a head-shield showing well the relative size of the cornua, anterior position of the orbits, and form of the posterior median prolongation of the shield. Compare this and figs. 2 and 3; their differences are simply due to different pressure and preservation. Cornstones. Dr. Grindrod.





J. Dinkel lith.

W. West imp.

C. MURCHISONI. AGASSIZII. POWRIEI

PLATE X.

Fig.

1. *Eucephalaspis* (*Cephalaspis*) *Powriei*. This most beautiful specimen shows the scales and fins in a marvellous state of preservation. The aspect presented is the ventral one, and the body has been twisted so that the marginal series of scales is on the right-hand side as one looks at the figure, whilst the dorsal series is on the left, as also the dorsal fin, the great lateral scales intervening. The form of the head (see also fig. 5, Pl. IX) contrasts forcibly with that of *C. Lyellii* or *C. Agassizii*, whilst the relative proportion of body and head is different from that presented by the specimens of *C. Lyellii* in Pls. VIII and XI. This specimen is from near Arbroath, Forfarshire, and is in Mr. Powrie's Collection.

2. Portion of the head-shield of a Cephalaspid from Forfarshire, showing the orbits as seen from below, with indications of blood-vessels passing in from the subjacent parts.

3. *Eucephalaspis* (*Cephalaspis*) *Pagei*, two thirds the natural size.

4. Another specimen, drawn of the natural size. These two specimens have been selected, as showing better than others in Mr. Powrie's magnificent series the surface markings and the scales. These scales are not well represented in fig. 3, in which it is not impossible that the ventral aspect is presented. The dorsal fin is well seen in fig. 4. The woodcut, fig. 21, gives a faithful outline of the head, restored from specimens less crushed than these are. Both from the Cephalaspis-bed, Lower Old Red Sandstone, near Reswallie, Forfar. In Mr. Powrie's cabinet.

4*a*, 4*b*. Represent magnified bits, showing the surface markings of some of the scales; 4*b* are, perhaps, ventral scales.

5. *Eucephalaspis* (*Cephalaspis*) *asper*. This specimen is in a grey nodule, the fossil itself having a red tinge. The polygonal areæ are very strongly brought out by the great pressure and the infiltration to which the shield has been subjected. A piece of the 'rim' of the shield has become detached, as also in the specimen in fig. 3. Mr. Powrie.

5*a*, 5*b*. Represent the under and upper surface of two of the scales of the preceding specimen, with some of the characteristic asperities.

PLATE XI.

Fig.

1. *Eucephalaspis* (*Cephalaspis*) *Lyellii*. Lateral view of the specimen from near Arbroath, Forfarshire, now in the Arbroath Museum. The head is not well preserved, nor is the material of the scales; but their order, and the pectoral, dorsal, and caudal fins are admirably displayed.

2. The same specimen, with a fragment of the body removed, displaying thus the *ventral series* of scales. The two pectoral appendages are well seen in this drawing, but the artist has introduced a joint-like structure in the right-hand appendage, which cannot be justified from the specimen itself. Compare the pectoral appendages of this specimen with those of *Eu. Powriei*, Pl. X, fig. 1.

3. Caudal fin of a *Cephalaspis*, from the same bed which contains *Eucephalaspis Pagei*, *Eu. asper*, and perhaps another species. Reswallie, Forfar. Mr. Powrie's collection.

4. A small specimen of *C. Pagei*, with the head so crushed as to give the cornua an increasedly incurved appearance.

C. LYELLII, PAGE.

PLATE XII.

Fig.

1. Head-shield of a small *Eucephalaspis* from Forfarshire. The outline agrees with that of the little specimen drawn in Pl. VIII, fig. 3.

2. A portion of the cephalic shield of *Zenaspis* (*Cephalaspis*) *Salweyi*, Egerton (= *asterolepis*, Harley). Cornstones, Herefordshire. In the Museum of the Geological Survey. The outline woodcut, fig. 26, has been drawn from a very much finer specimen, which I obtained too late to figure in a plate. For the dorsal scutes of this species see Pl. VIII, figs. 2 and 3.

3. *Hemicyclaspis* (*Cephalaspis*) *Murchisoni* = *C. ornatus*. From the Passage-beds near Ludlow. In Mr. Lightbody's collection.

4. A similar specimen belonging to the Rev. P. B. Brodie. This and the above are the specimens figured by Sir Philip Egerton, 'Quart. Journ. Geol. Soc.,' vol. xiii, pl. IX, 1857.

   Compare these two specimens with those from the Ledbury beds, Pl. VIII, fig. 6, and Pl. IX, fig. 1. Their identity is fully proved by the ornament.

5. *Cephalaspis Salweyi*. Sir Philip Egerton's figured specimen, *loc. cit.* Cornstones of Acton Beauchamp, near Ludlow. Mr. Humphrey Salwey.

6. A specimen from the same locality, and probably referable to the same species. The oblong form and inequality of the tubercles on the surface at one time appeared to me to separate *C. Salweyi* from *C. asterolepis*, but a distinction cannot be maintained on these grounds, since the tubercles are equally irregular in specimens referred to *C. asterolepis*. This and the more perfect specimen with cornua in the British Museum are rather small specimens of the species. The cornua, which are long and rounded, are not preserved in this specimen. See the woodcut, fig. 26, page 53. This specimen belongs to Mr. Humphrey Salwey.

1
2
3
4
5
6

PLATE XIII.

FIG.

1. *Didymaspis Grindrodii.* The shield is imbedded with its concave surface upwards. Dr. Grindrod's collection.
2. Natural cast of the same. From the red micaceous beds above the Auchenaspis Grits of Ledbury. The artist has not fairly represented the character of these specimens, which are better seen in vol. iv of the 'Geological Magazine,' pl. viii, figs. 4 and 5.
3. *Auchenaspis Egertoni.*
4. „ „
4*a*. A part of fig. 4 enlarged, showing the orbits, antorbital fossæ and their septum, the superficial lamina which covers them in having been broken away, and the hexagonal areolation of the material of the test. The surface is not preserved; it is tuberculated, as in *Cephalaspis.*
5. A part of fig. 4 enlarged. The difference in form and size of the cornua in these specimens is due to the more or less covering by matrix, a condition which the artist has not rendered apparent in these or the other figures.

3, 4, and 5 are from the Auchenaspis Grits (Passage-beds), Ledbury, and belong to Dr. Grindrod.

6,6*a*. Fragments of scales from beds at the base of the Cornstones, Ledbury. Dr. Grindrod.

7, 8. *Auchenaspis Salteri.* The Passage-beds near Ludlow. Mr. Lightbody.

9—14. *Eukeraspis* (*Auchenaspis?*) *pustuliferus,* from the Downton Sandstone of Ludford Lane, near Ludlow.

9. Central part of the head-shield, showing the orbits and finely tuberculated ornament in intaglio. The margin is fractured, and has not the regularity here given by Mr. Lightbody.
10. Fragment, showing the central part of the shield, enlarged. Dr. Grindrod.
10*a*. The tubercular ornament still more enlarged.
11. One of the long cornua, showing the denticulations on the outer margin which led to such specimens being considered as the jaw of a fish, the *Plectrodus pustuliferus* of Siluria. Mr. Lightbody.
12. A specimen showing the marginal cavities or cells exposed by the breaking away of the upper surface of the shield. Dr. Grindrod.
13. A specimen which shows well the form of the shield and cornua (see woodcut, fig. 31). The whole of the superficial lamina of the test is gone, and the subjacent cavities and laminæ exposed. The part here preserved appears to agree with the anterior moiety of a shield of *Auchenaspis* or *Didymaspis.* The two bodies which have the appearance of orbits are cavities underlying the shield surface, like the marginal cells. The true orbits lie anteriorly to this. Compare the figure of these genera. Mr. Lightbody.
14. A fragment which shows beautifully the impression of one of the long cornua and a part of the head. The denticulations of the margin are not drawn finely enough, and the cornu is represented as thicker than it is really. Mr. Lightbody.

15, 16. Fragments, the like of which are not uncommon in the lower parts of the Cornstones of Herefordshire, probably the angles or cornua of Cephalaspidian shields which have been rolled and washed. Dr. Grindrod.

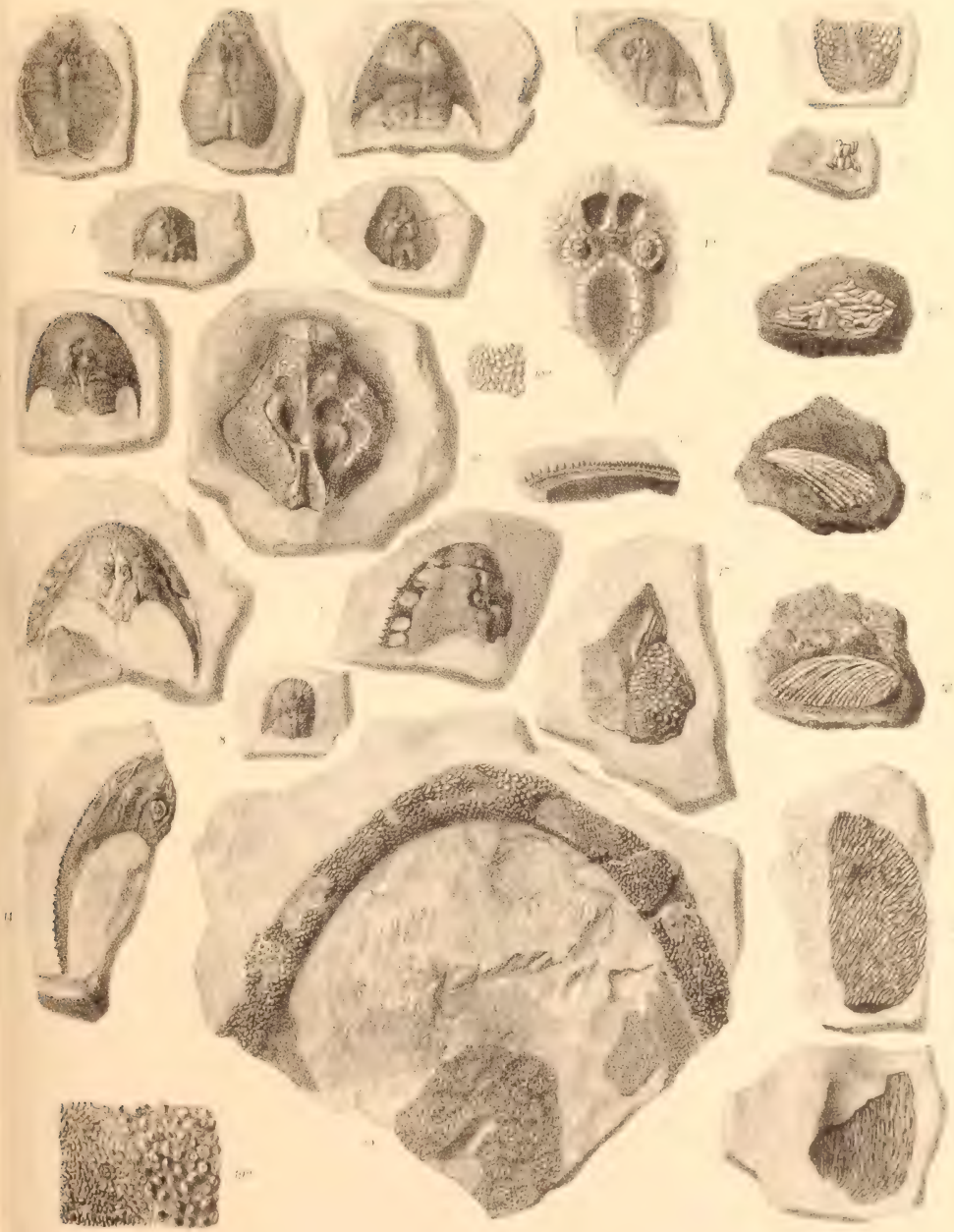
17, 18. Mesially placed scutes belonging to some Cephalaspid of the same character and mode of occurrence as figs. 15 and 16. A specimen of very much larger size, similar to fig. 17, has come under my notice, and appeared to belong to *Zenaspis.* It is not figured in this work. Compare Pl. VIII, figs. 2, 3, and 4, with these. Dr. Grindrod.

19. *Cephalaspis Lightbodii,* from the Passage-beds near Ludlow; the under surface of a very large and characteristic marginal rim is presented; in the lower part of the specimen a portion of perhaps the dome of the shield is seen in intaglio; more probably this belonged to an additional scute. Mr. Lightbody.

19*a*. A part of the tubercular ornament enlarged.

20. *Kallostrakon podura.* Lower Cornstones, Herefordshire. Dr. Grindrod.

21. Intaglio of a similar fragment, differing a little in the character of its markings. Dr. Grindrod.



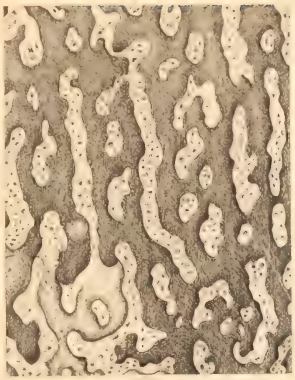
J. Dinkel lith.

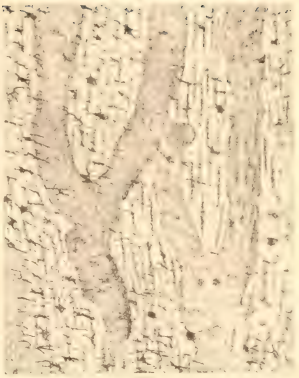
AUCHENASPIS, KALLOSTRAKON &c.

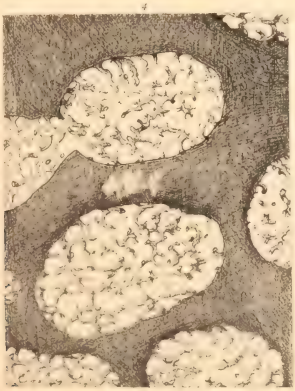
PLATE XIV.

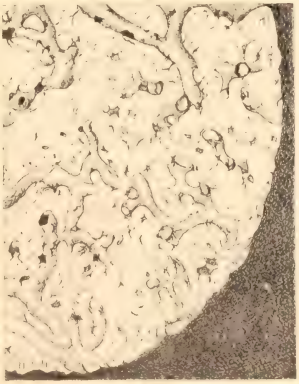
Fig.

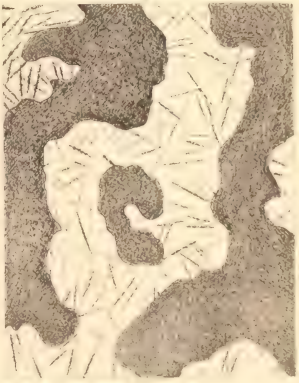
1. Horizontal section about the middle layer of the shield of *Zenaspis*, magnified 50 diameters.
2. The same, magnified 200 diameters.
3. Horizontal section of the lower layer of the same, magnified 200 diameters.
4. Horizontal section of tubercles of *Zenaspis*, magnified 30 diameters.
5. The same, magnified 120 diameters.
6. Horizontal section of a portion of the scale of *Kallostrakon podura*, magnified 200 diameters.
7. A portion of the shield of *Zenaspis Salweyi*, magnified 4 diameters. The substance of the shield is worn away from the right down to the left side of the specimen, and thus the successive layers are exposed; on the right hand top corner the shining tubercular surface; below this the radiating stellate forms due to the disposition of the vascular canals; below this again simple hexagonal or multiangular pieces completely emarginated by canals; and lastly, horizontal branching canals, causing the "fibrous structure" spoken of by Agassiz. Vertical canals are seen in section as minute dots in all the different thicknesses.
8. Vertical section of a part of the shield of *Cephalaspis Lyellii*, copied from Prof. Huxley's paper in 'Quart. Journ. Geol. Soc.,' vol. xiv, 1858.

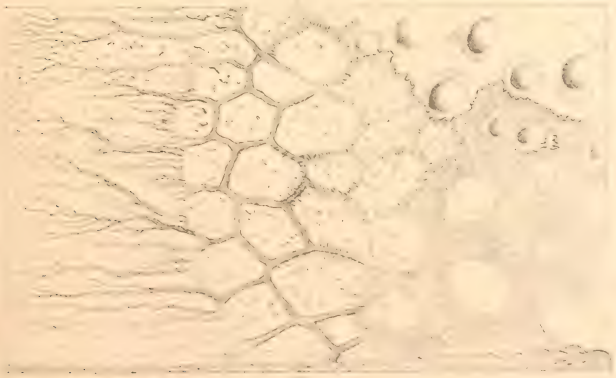












THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1869.

LONDON:
MDCCCLXX

MONOGRAPH

OF

THE FOSSIL REPTILIA

OF THE

LIASSIC FORMATIONS.

BY

PROFESSOR OWEN, F.R.S., D.C.L.,

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,

ETC. ETC.

PART SECOND.

PTEROSAURIA.

Pages 41—81; Plates XVII—XX.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1870.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

MONOGRAPH

OF

THE FOSSIL REPTILIA

OF THE

LIASSIC FORMATIONS.

Order—PTEROSAURIA, *Owen.*

Genus—Dimorphodon, *Owen.*

Species—Dimorphodon macronyx, *Buckland.*

Remains of volant Reptiles (*Pterosauria*) were later recognised, and, save in the instance about to be recorded, in a more fragmentary or scattered condition, in England than in Continental localities.

A single bone or tooth gives value to a slab of Stonesfield Slate, and the evidence of a Pterodactyle rarely goes beyond such specimen in that Oolitic deposit. A jaw with teeth, or a skull more or less entire, from the Chalk of Kent, or the Upper Green-sand of Cambridge, has been welcomed for the fuller information so yielded; and such fossils, with a few detached vertebræ and wing-bones, have expanded our conceptions of the bulk attained by some of the Flying-dragons at the decline of the Mesozoic period.

When the waters over which they flitted had a clayey or muddy bottom it afforded a quieter resting-place to the dead body of the Pterosaurian therein entombed. So the first discovered specimen of one of these in the upraised petrified ocean-bed now forming the Liassic cliffs of western Dorsetshire afforded Buckland[1] subjects, in the compass of a slab about a foot square, for a description and figures of the leg and wing-bones, with part of the

[1] "On the Discovery of a New Species of Pterodactyle in the Lias at Lyme Regis." By the Rev. W. Buckland, D.D., F.R.S., F.G.S. (Read Feb. 6, 1829.) 'Transactions of the Geological Society of London,' second series, 4to, vol. iii, 1835, p. 217, pl. xxvii.

vertebral column, of the species which he called *Pterodactylus macronyx*—the first evidence of the genus from deposits so low, or ancient, in the Oolitic series.

In 1858 I obtained the skull, with a few other parts of the skeleton of the same or a closely allied species, from the Lower Lias at Lyme Regis, and communicated a brief notice of it to the British Association, which that year met at Leeds.[1]

This specimen confirmed the accuracy of Buckland's conjecture, which I had doubted, viz., that the portion of lower jaw with the series of small lancet-shaped, close-set teeth,[2] in a second slab of Lias, belonged to the same Pterodactyle as the limb-bones he described; but it also showed that these teeth, so like those of some Fishes, were limited to the lower jaw, and were associated, in the same mouth, with long, slender, trenchant and sharp-pointed laniaries, projecting with wide intervals, and set in advance; which kind of teeth had, hitherto, alone been found in the different species of flying Reptiles.

The chief result of the study of the second discovery of a Pterosaurian in Lias, viz., its evidence of a new generic form (*Dimorphodon*) in the order of volant *Reptilia*, in addition to *Rhamphorhynchus*, von Meyer, and *Pterodactylus* proper, was noted in the communication above cited.

The third specimen about to be described confirms that taxonomic deduction, showing a combination of the caudal character, mainly differentiating *Rhamphorhynchus* from *Pterodactylus*, with the dental character above defined.

I propose first to describe and figure the two specimens yielding the cranial and dental characters of *Dimorphodon*, and then to attempt a restoration of the Liassic species, *D. macronyx*.

The first specimen with the skull is figured in Pl. XVII. It is on a slab of Lias, measuring 11 inches by 7 inches. The right side of the head is exposed:[3] it has been subject to pressure and some degree of dislocation. Certain bones of both wings, and a few other parts of the skeleton are preserved, pell-mell, in this slab, pressed amongst and upon the bones of the head, especially at the back part of the skull.

The right premaxillary (22), maxillary (21), and nasal (15), are almost in their natural positions, give the profile contour of that part of the skull, show most of the teeth of the right side upper jaw, and reveal the singular expansion of the nasal (*n*) and antorbital (*a*) vacuities. The alveolar part of the left maxillary (8′), with its ascending postnarial branch has been pushed obliquely downward, with fracture, but without much displacement, of the beginning of the alveolar ray, the inner surface of which is exposed.

The mandible (32) has been dislocated and pushed below the place of its articulation with the tympanic (28): the left ramus has also been subject to the same force which has

[1] "On a New Genus (*Dimorphodon*) of *Pterosauria*, with Remarks on the Geological Distribution of Flying Reptiles;" in 'Reports (Sections) of the British Association,' 1858, p. 97.

[2] Buckland, loc. cit., pl. xxvii, fig. 3.

[3] The specimen has been drawn, in Pl. XVII, without reversing.

dislocated that side of the upper jaw: the hind part of this ramus is obliquely depressed, so as to expose the inner surface (32).

The anterior entire or undivided part of the premaxillary (22) is about 2 inches in length, and $1\frac{1}{4}$ inch in vertical height at its back part: it contains four pairs of teeth, which are the largest and longest of the series. The foremost tooth (1) is terminal, with a crown 5 lines in length, rather over 1 line in breadth (fore-and-aft) at its base: it is subcompressed, subrecurved, and sharp-pointed. An interval of 4 lines divides it from the second tooth (2), with a crown $5\frac{1}{2}$ lines long. After an interval of 7 lines projects the crown (3) of the third tooth, 7 lines in length and 2 lines in basal breadth, sharp-pointed like the first, but less bent. The socket and base (?) of the fourth tooth appear at an interval of 6 lines, and below is the entire and displaced homotypal tooth (4) of the left side, showing the cavity on the inner side of its root which would have received the successional laniary. This tooth measures 1 inch 2 lines in total length, of which the exposed enamelled crown forms two-thirds. In advance of the foremost tooth (1) is seen part of its homotype (1′) of the left side, also displaced from the socket, and showing the depression and vacuity on the inside of the base, in relation to the succeeding tooth. Beyond the fourth alveolus the maxillary (21) appears, underlapping the part of the premaxillary (22^{a}) which defines the lower and anterior part of the narial vacuity: the maxillary is continued straight backward, with feeble indications of two crushed alveoli (5, 6) for 1 inch 9 lines, when the seventh laniary (7) projects almost straight downward: the crown of this tooth is 5 lines long; the root, covered with rougher cement, slightly contracts to its implanted end, which has slipped a short way out of its socket. An interval of 4 lines divides this from the next laniary (8), which shows a crown of but 3 lines in length; this projects opposite the fore part of the lateral post-narial branch (21^{a}) of the maxillary. The base of the left homotypal tooth (8′) projects from the same part of the dislocated left alveolar branch of the maxillary; and above this, on the inner side of that bone, is exposed the coronal germ of a successor. In the right maxillary two other straight laniaries (9, 10) of rather decreasing length, project with similar or rather lessening intervals: then follows, after an interval of 3 lines, a pointed compressed crown $1\frac{1}{2}$ line in length (11); and, at shorter intervals, two smaller pointed compressed teeth (12 and 13).

These thirteen cuspidate teeth of the upper jaw are included in an extent of the alveolar border measuring 5 inches 2 lines. That border is continued backward, straight and edentulous, for 9 lines beyond the last tooth, when it is crossed by the large and long first phalanx (μ 1) of the wing-finger. This edentulous part of the maxillary forms the lower straight border or base of the large triangular antorbital vacuity (a), at the back part of which it is overlapped by the fore part of the slender malar (26). Above this vacuity are parts of the nasal (15) and prefrontal (14), both somewhat displaced in this crushed part of the skull. The arched part of the frontal forming the upper part of the rim of the orbit (o) is recognisable at (11) Pl. XVII. Above its hind part are indications of the post-frontal (12) and mastoid (8), with the process of the latter descending external to

its articulation with the tympanic (28). The metacarpus and dislocated unguiculate digits of the wing-limb are confusedly interblended with the crushed and dislocated back part of this skull; three phalanges (*IV* 1, *IV* 2, *IV* 3) of the wing-finger are determinable.

The two anterior teeth (1′, 2′) of the mandible show longitudinal angular depressions at their base, indicating exposure of their inner side, and that they belong to the left ramus. The corresponding part of the right ramus may have been broken away: the third laniary (3′) clearly belongs to this ramus, which is fractured beneath its socket. The point of this tooth is broken off: what remains of the body is curved, and is implanted more obliquely backward than the two preceding teeth. This at first led me to suspect it might be the foremost tooth of the mandible, and that the left ramus had been pushed in advance as well as downward: but my doubts on this point have been set at rest by the specimen (Pl. XVIII) next to be described, and I view the tooth in question as the third of the mandibular series: it is divided from the second by an interval of 6 lines, and the second stands at a rather shorter interval behind the first. Five lines behind the third tooth is the base of a fourth laniary (4′), and four lines further back is an indication of a fifth (5′). This is followed by the characteristic series of between thirty and forty very small, subcompressed cuspidate teeth, each less than a line in length, corresponding in extent with the maxillary part of the upper jaw. The entire series of mandibular teeth occupies an extent of alveolar border measuring 5 inches 1 line.

The depth of the right ramus gradually increases from 5 lines below the last laniary to 10 lines below the last denticle. The inner side of the dislocated ramus (32′) shows a strong longitudinal ridge projecting inwards about 3 lines above the lower border. The outer surface of the ramus seems to have been strengthened near its lower border by a similar but lower ridge.

The distal ends of the antibrachial bones (54, 55) overlap the hind part of the mandible: that which shows the larger articular surface, opposite the three slender metacarpals, should be the radius. The base of the supplementary styloid bone appears near the distal end of the ulna, but is better shown in Buckland's original specimen.[1] Indications of two carpals intervene between these and the metacarpus. This overlies and conceals the articular pedicle of the mandible and contiguous parts (squamosal, malar, &c.) of the skull. The metacarpus includes the three slender supports of digits *I*, *II*, and *III*, and the strong and thick metacarpal of the wing-finger (*IV*). This bone, being almost concealed by the first phalanx in Buckland's specimen, was overlooked, and that phalanx was described as the metacarpal of the wing-finger, which, accordingly, in the restoration, fig. 2, Pl. 27, of 'Buckland's Memoir,' is made three times the length of the other and more slender metacarpals (3′). I have, therefore, had that part of the original specimen, now in the British Museum, redrawn (Pl. XIX, fig. 1), the true metacarpal being shown at *m* 4. It corresponds with the same bone in previously described *Pterosauria* by surpassing in thickness, not in length, the other constituents of the metacarpus. In the specimen,

[1] As in the part re-drawn in fig. 1, Pl. XIX.

Pl. XVII, the metacarpal of one wing-finger is clearly shown at m^{3}. That of the other, lying upon the cranium, is more obscure. The thin compact wall of this pneumatic bone has been crushed in upon the wide air-cavity, as with most of the other long bones, so that it looks like two metacarpals. The proximal articular surface of m^{3} is partly concave and partly convex: the distal articulation is trochlear, moderately concave from side to side at the middle, convex from behind forward, with a depression behind, above the articulation, for securing the olecranoid process of the proximal phalanx. This phalanx ($_{IV}$ 1), in one wing, is bent back upon the fore-arm, crosses the dislocated mandible, and has been pressed upon it, long and hard enough to leave a channel in the right ramus, where part of the phalanx has been removed: its length is 4 inches 6 lines.

The second, more slender and longer phalanx ($_{IV}$ 2), is bent at nearly a right angle with the first, and lies below and parallel with the mandible: it is nearly 5 inches in length. The third phalanx ($_{IV}$ 3) is bent upward in front of both lower and upper jaws: $4\frac{1}{2}$ inches of its length is preserved in the slab: from the analogy of the better preserved specimens (Pl. XVIII, $_{IV}$ 3), about 1 inch 3 lines are wanting from the distal end.

Of the three unguiculate digits the characteristic large claws are preserved: one ($_{II}$) lies above the frontal (11) with the penultimate phalanx; the other two are between the upper and lower jaws, with some of the slender phalanges: all these parts of the ramus having been dislocated and scattered.

Parts of the distal ends of the radius and ulna (54′, 55′), the metacarpal of the wing-finger (m^{4}), and the proximal end of its first phalanx ($_{IV}$ 1), of the opposite fore-limb, occupy a lower corner of the slab: carpal bones, one of the accessory styloid ossicles of the forearm, some of the slender metacarpals of the claw-fingers can be made out above these: and there are more obscure indications of vertebræ at that end of the slab, curving toward the cranium.

All the osseous and dental textures are black, as if charred by slow combustion of the animal matter.

Dimorphodon macronyx. Pl. XVIII.

In August, 1868, I was favoured by the Earl of Enniskillen, then at Lyme Regis, Dorsetshire, with a list of parts of a Pterodactyle, in a slab of Lias about 20 inches by 11 inches, and of other parts in detached portions of Lias, including the entire tail with its bone-tendons, which his Lordship had observed at Messrs. James and Henry Marder's, the judicious and persevering collectors of the fossils of that rich locality.

The result of this valuable and timely information was the securing for the British Museum the entire series of these Pterosaurian fossils.

They proved to be parts of the *Dimorphodon macronyx*, confirmed many of the observations made on previously acquired specimens, corrected others, and added almost all that was required for the restoration of the skeleton of this remarkable genus and species, which I have accordingly attempted in Pl. XX.

The slab of Lias with the second specimen, including the skull of *Dimorphodon macronyx*, is of larger size, shows more of the skeleton and in a more separated and definable state than in Pl. XVII. Nine dorsal vertebræ, third to eleventh inclusive, in natural juxtaposition, with the twelfth slightly dislocated, are preserved at the upper part of the slab (Pl. XVIII, D). The summits of the neural spines ($_{ns}$) of most of these, and the disposition of many of the preserved ribs, show that they lie mainly with the dorsal aspect downward (as the specimen is figured). This explains and accords with the position of the parts of the pelvis, which lie a little way behind the dorsal vertebræ. The comparatively slender ilium ($_{62, 62}$) is downward ; the broad ischium ($_{63}$), and the pair of spatulate pubic bones ($_{61}$), are turned, like most of the ribs, upward, as I conclude the abdominal or ventral surface of the trunk was directed as the fossil lies in the figured slab. The bones of the hind-limb, in connection with the acetabulum, are turned outward, with their inner surface exposed. The projections of the trochlear terminations of the metatarsals (*i, iv*, $_{69}$), show that the sole of the foot is turned to view. Accordingly, we have here the bones of the left hind limb. On the hypothesis that the femur and tibia are seen from the outside, which at first suggests itself, they would belong to the right limb, viewed in profile. But then, the broad thin plate of bone contributing to the acetabulum, would represent the ilium, and the indications of the pelvis below the acetabulum and head of the femur would represent ischium and pubis. This interpretation, however, gives to *Dimorphodon* proportions of pelvic bones very different from those determined by Wagner in *Pterodactylus Kochii*,[1] and by Quenstedt[2] in *Pterodactylus suevicus ;* and, besides, it leaves undetermined the pair of bones (64, Pl.XVIII) which closely resemble in form and proportion the 'pubic bones' (*u, u*) in Quenstedt's instructive plate.[3] In this plate the ilia (*s, s*) are represented as long slender bones, contributing the upper but smaller proportion of the acetabulum, and extending horizontally beyond it both forward and backward. The pelvis, in the position in which I conclude it to lie in the slab figured in Pl. XVIII, might well afford such indications of the pre- and post-acetabular productions of the ilium as are there shown at $_{62, 62}$. In *Pterodactylus suevicus* the ischium contributes the lower and major half of the acetabulum (*tr*, loc. cit.), and expands into a broad thin plate (*s*, ib.), having the proportions to that of the spatulate pubis, which the bone $_{63}$ bears to $_{61}$, in Pl. XVIII. The portion of the pelvis in the original specimen being preserved in natural connection with

[1] "Ueber *Ornithocephalus Kochii*," in 'Abhandl. d. math.-phys. Klasse der Bayerischen Akad.,' ii, 4to, München, 1837.

[2] 'Ueber *Pterodactylus suevicus*,' &c., 4to, Tübingen, 1855.

[3] In the Memoir above cited.

the sacrum and contiguous vertebræ is figured in Pl. XIX, fig. 2; and the constituent bones are rightly recognised by Buckland (op. cit., p. 222).

It is interesting to note, that the pelvis of *Pterosauria*, so determined, resembles more closely that of the existing representatives of the section of *Reptilia* with the 4-chambered heart and double-jointed ribs, viz., *Crocodilia*, than it does the pelvis in *Chelonia* and *Lacertia*. The ischium in *Crocodilia*, *e. g.*, surpasses the pubis in size, and excludes that hæmapophysis from the acetabulum.[1] The ischium seems to contribute the larger share of the acetabulum in *Dimorphodon*, Pl. XVIII, *a*. In Birds, as in Lizards, the pubis forms part of the acetabular cavity.[2]

In the specimen, Pl. XVIII, a portion, *cd*, of a long tail, of which the vertebræ were surrounded by numerous slender bone-tendons, extends backward and downward beyond the pelvis: a better preserved portion with three caudal vertebræ (*c d*) is preserved in a detached part of the matrix found in the vicinity of the larger slab. But to this part of the vertebral column I shall return in describing the more perfect specimen of the tail of *Dimorphodon*, from another individual (Pl. XIX, fig. 4).

Behind the skull are four cervical vertebræ (Pl. XVIII, c), and part of a fifth in natural juxtaposition, or perhaps a little separated at the articular surfaces. The under surface of the centrums and articular processes of the neural arches are exposed. The sides of the centrums show a slight concavity, but their crushed state obscures the natural contour of the under surface. The hind part of the under surface, in the last two of these vertebræ, shows a pair of low obtuse processes, with an indication of a convex terminal articular surface. The centrum expands in breadth as it advances, and sends out a short thick process (parapophysis) from each side of the fore part; to which, in the last three vertebræ, are indications of attachment, or parts, of a backwardly produced styliform rib. At the midline of the fore part of the last two of these vertebræ a fracture indicates a ridge or process there to have been broken off. The pre-zygapophyses are thick, and project far in advance of the concave anterior articular surface of the centrum: the convex posterior articular surface of the centrum projects as far beyond the post-zygapophyses. Their joints are more vertical than horizontal: the posterior surfaces looking slightly outward and downward.

The superior breadth of the neural arch, as compared with that of the centrum, brings its articular processes into view, along each side of the vertebral bodies, in the degree shown in Pl. XVIII, c. The character of the articulations indicate less extent and freedom of movement of the cervical vertebræ than in Birds, and more restriction in the lateral than in the vertical directions. The interlocking joints resulting from the different lengths of the fore and hind articular processes add strength to the part of the spine supporting the head.

The cervical vertebræ of *Dimorphodon*, so far as their structure is exemplified in the

[1] 'Anatomy of Vertebrates,' vol. v, p. 188, fig. 119.

[2] Ib., p. 190.

present specimen, conform to the pterosaurian characteristics of these vertebræ, as shown in those of *Pterodactylus Sedgwickii*, described and figured in the 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' Supplement No. 1 (1859), pp. 7—10, Pl. II, figs. 7—18; and in those of *Pterodactylus simus*, ib. Supplement No. III (1861), p. 7, Pl. II, figs. 1—5.

The skull preserved in the present specimen agrees in size with that in the slab previously received (Pl. XVII), repeats the characteristics of the genus *Dimorphodon*, and shows no differences of greater degree or value than may be set down to individual modifications. The part defective and partly obscured by intrusive bones from other parts of the skeleton is unfortunately that which leaves the precise determination of structure unsatisfactory in the previously described specimen. A trace only of tympanic remains at 28, and of the descending styloid process of the mastoid at 8: the thick metacarpal of the wing-finger (iv, *m*), intrudes into the orbit, and overlaps the upper end of the malar (26). More of the part of the frontal forming the superorbital arch (11) is shown than in Pl. XVII. Part of the concave surface of the orbital cavity beneath the superciliary ridge is here seen. The lacrymal (23) or descending branch of the prefrontal (14) meets the ascending process from the combined malar and maxillary, dividing the orbital from the antorbital cavity. The true size and shape of the latter vacuity (*o*) is here well displayed. The maxillary styloid process (21^{x}) rises, at the same angle backward as in Pl. XVII, to join the nasal (15). The medial branch or ray of the premaxillary ($22'$), the end of which is depressed below the prefrontal in Pl. XVII, preserves its position in the present specimen, and yields the true arched contour of the profile of this remarkable skull.

The entire vertical extent of the vast narial vacuity, *n*, is here given, the longitudinal one, $3\frac{1}{2}$ inches, precisely agreeing with that in the first-described skull. The anterior part of the premaxillary (22) shows, also, the same proportions and shape, viewed sideways, as in the first specimen. The conformity is instructively continued in the characters of the dental system. The apex of the crown of the laniary (Pl. XVIII, 1) from the fore end of the premaxillary shows the same curvature and proportions as in Pl. XVII; the same interval divides it from the second laniary (2); the longer interval, again, occurs between the second and the third laniary, with a longer and less curved crown. After an interval of seven lines comes the fourth tooth (4), corresponding in size and shape with the one which is displaced in Pl. XVII, $4'$. After an interval of nine lines the apex of the crown of, seemingly, the successor of the fifth laniary (5) appears. It may be, normally, smaller than the rest; the socket of this tooth is feebly indicated in the subject of Pl. XVII. The sixth laniary (6) shows the same size and relative position as in that subject, and the same may be said of the five succeeding teeth, save that the last is rather larger than in Pl. XVII, which also shows an additional small hind cuspidate tooth. The suture between the premaxillary ($22''$) and the maxillary (21) is more plainly discernible in the present specimen.

The extent of alveolar surface of the left upper jaw occupied by the above-described dental series is 5 inches 3 lines.

In the left ramus of the mandible two of the large anterior laniaries are in place; one, answering to the second in Pl. XVII, 2′, projects across the diastema between the second and third tooth above; in size, shape, and curvature, it resembles the second upper laniary, close to which it terminates. The next mandibular tooth is larger, less curved, and crosses the middle of the interval between the third and fourth upper laniaries. The tooth (1′) displaced beneath the mutilated fore part of the mandible, I take to be the foremost of the mandibular series and suppose that its point would naturally project across the interval between the first and second of the upper teeth. The fourth laniary appears to be more displaced: its base or root, with a lateral depression, is shown behind the fifth tooth of the minute serial teeth, and the crown passes obliquely backward on the inner side of that of the sixth upper laniary, by which it is concealed. Of the serial teeth, with pointed crowns from half a line to a line in length, about thirty may be reckoned occupying an alveolar extent of 2 inches, 9 lines.

At the hind part of the left mandibular ramus, here exposed, three longitudinal ridges define two vacuities, of which the inferior may be natural. The upper one seems more plainly due to loss of the thin outer plate of bone extended between the upper two ridges. The proportions of the ramus closely accord with those of the first-described specimen. The fore part of the mandible is too much mutilated for useful comparison.

The dentition of *Dimorphodon*, as displayed by the second specimen of skull, consists, in the upper jaw, of laniaries with wide intervals, eleven in number on each side; in the lower jaw, of four, if not five, laniaries implanted at the fore part of each ramus of the mandible at intervals corresponding with three of the four anterior laniaries above; then follows the long series of close-set and minute pointed teeth. The difference of dentition as compared with the first specimen (Pl. XVII) is, in the upper jaw, in the additional small laniary or cuspidate tooth at the back part of the series in that specimen. In the lower jaw there does not seem to be any noteworthy difference in the number, kinds, and position of the teeth. The longest laniaries are included between the second and fifth in both jaws: the upper laniaries after the fourth become small and straight.

At the first view of the framework of the huge head of our Liassic dragon one is struck with the economy of bony material and the purposive skill with which it has been applied or disposed, so as to give strength where resisting power was most required.

The lodgment of the poorly developed brain enlists a miserably small proportion of the skull: the cranium proper, or brain-case, is relegated to an out-of-the-way corner, so to speak, and there it is almost concealed by the projections for joints or muscular attachments. The orbits accord with the large eyes given to this volant and swift-moving Reptile.

One can conceive no necessary interdependent relation between the wide external bony nostril (*n*) and the organ of smell, nor be led to conjecture that the tegumentary inlets to the nasal chamber were larger than is usual in Reptiles.

The main purpose of the head is for prehension of prey. The jaws are produced far

forward to form a wide-gaping mouth, and are formidably armed. We may conceive, therefore, that the dragon may have occasionally seized an animal of such size as to require considerable force of jaw for overcoming its struggles. The means of resistance were afforded to the upper or fixed maxilla, not by a continuous wall of bone, but by curved columns or abutments. The chief of these is the upper medial arch of bone which overspans the skull lengthwise, from the short roof of the cranium to the fore part of the premaxillary (22); the frontals (11) and nasals (15) combining with the mid-fork or branch of the premaxillary (22′,) to constitute this arched key-ridge of the roof of the head.

From it two piers or buttresses out-span on each side, to give strength and resistance to the upper jaw, and especially its alveolar tracts. One, proceeding from the nasal, meets the uprising process of the maxillary (21); this abutment, curving from above outward and obliquely forward, expands and backs the part of the jaw where the second group of large laniaries project. The second buttress is continued from the prefrontal (14), and arches more directly outward to meet the uprising process of the malo-maxillary. A third arch, due to the post-frontal (12) and malar (26), expands to abut upon the hind end of the maxillary arch, and gives support to the part of the skull which the temporal muscles tended to pull downward when they were giving to the mandible the power of a strong bite or grip. Finally, comes the strongest of the four piers, due to the mastoid (8) and tympanic (28), for giving articular attachments to the rami of the lower jaw.

Thus, four vacuities appear in the side-walls of the skull: the first (n) is the largest, between the small consolidated or continuous fore part of the skull (22), and the naso-maxillary pillar (21^{x}, 15). This vacuity answers to the external bony nostril of the same side, in the Lizard's skull (Pl. XX, fig. 3, n), where the nostrils are divided and more or less lateral. The second vacuity (a) is somewhat less, of a triangular form, with the base downward: it answers to the antorbital vacuity in *Lyriocephalus* (ib., a) and a few other Lizards, and to that in *Teleosaurus*, where, however, it is very small. The third vacuity (o) still decreasing, is oval, with the narrow end or apex downward: it answers to the orbit, but is of large size compared with most Saurians; it is, however, exceeded in relative expanse by the orbit in *Lyriocephalus* (ib., o).

The fourth vacuity is the narrowest: it answers to the so-called 'temporal fossa' and was occupied by the muscles of the same name. Extension of surface, for their origin, and additional strengthening of this back part of the skull are gained by laying horizontally across the temporal fossa the bony beams called 'upper and lower zygomata,' arching from the postfronto-malar to the masto-tympanic vertical columns. The heavy phosphate of lime, thus singularly economised by the disposition of the bones on mechanical principles plainly to that end, is made to go still further by the arrangement of the osseous tissue. Every bone is pneumatic, the abundant, open, cancellous structure being included in a very thin layer of compact osteine.

The bones of the limbs are dislocated and dispersed in the way and degree common to the specimens of this animal hitherto discovered (Buckland, loc. cit., pl. xxvii; and pls. XVII and XVIII of the present Monograph). The scapula (Pl. XVII, 51) and coracoid (ib., 52) in the same anchylosed condition as in the first-described specimen, are at the end of the slab opposite to that with the head. The corresponding humerus (53), preserved in a separate portion of the block of Lias, shows the entire contour of the pectoral process (*b*). The right humerus (53′) lies below the dorsal vertebræ (D); the upper part of the pectoral process (*b*) is wanting, but the obtuse thickening of the end of that remarkable production is well shown. The ridge (*c*) called 'ulnar,'[1] descending from the 'lesser tuberosity,' appears in this view of the 'palmar' surface of the bone.[2] The sigmoid flexure of the shaft is much better marked than in the humerus of *Pterodactylus suevicus*.[3] The stronger walls of the humerus have resisted the pressure better than those of most of the other long bones.

Of the antibrachial bones parts of the shafts, crushed, are seen at 54, 55, apparently of the right wing. With the distal ends of these, the right carpus (56) and metacarpus (57) appear to have retained their natural connections. The slender metacarpals of the first (I), second (II), and third (III) digits appear emerging from beneath the left hind foot which overlies their proximal ends. The phalanges of the first digit (I), two in number, preserve their natural articulations. As are also those of the second digit, three in number. The metacarpal of this digit is longer by $2\frac{1}{2}$ lines than that of the first. The additional phalanx would seem to be the proximal one, by its shortness: the second phalanx more nearly agrees in length with that supporting the claw-phalanx in the first digit; but it is thicker and a little longer. The four phalanges of the third digit (III) are dislocated; but the penultimate, which is the longest, retains its connection with the ungual phalanx. The proximal phalanx is longer than the second, which resembles in length, and seems homotypal with, the proximal phalanx of the second digit. It may be concluded, therefore, that the additional phalanx to II and III was developed at the attachment of the digit to the metacarpus. The largely and abruptly expanded metacarpal of the fourth digit is in great part covered by the correspondingly thickened and much elongated phalanx (*IV*, 1) therewith articulated. The olecranoid process of this phalanx is well shown, and the entire bone is preserved: its length is 4 inches 2 lines: it is bent directly and abruptly back upon its metacarpal. To the distal end is attached part of the second phalanx (*IV*, 2).

The proximal phalanx of the left wing-finger is preserved in a detached (*IV*, 1) part of the slab (Pl. XVIII) containing the major part of the skeleton. The second phalanx (*IV*, 2) of the left wing-finger lies in that slab, is entire, and yields a length of 4 inches 9 lines. The third

[1] 'Monograph on Fossil Reptilia of Cretaceous Formations,' Suppl. No. iii, 1860, p. 14, pl. iii, fig. 1, *c*.

[2] Op. cit., 190.

[3] Quenstedt, op. cit., *c l*, *c r*.

phalanx ($_{IV,3}$) is 5 inches 6 lines in length; near its distal end is part of the slender terminal phalanx of this digit ($_{IV,4}$). There is no trace of a fourth unguiculate digit, and I return to Cuvier's view of the structure and homologies of the hand of the Petrodactyle,[1] which I had abandoned in favour of the seemingly more perfect evidence supporting Professor Goldfuss' restoration of *Pterodactylus crassirostris*,[2] adopted by Buckland[3] and myself.[4]

The metacarpal of the left wing-finger ($_{IV,m'}$, Pl. XVIII) lies beneath the back part of the skull, and is over-lapped by the superorbital part of the frontal. Portions of two of the unguiculate digits of the same fore-paw ($_{I,II}$) are seen in the wide narial vacuity.

The definition and finish, so to speak, of the joints of the wing-finger are worthy of note, especially of that between the metacarpal bone and proximal phalanx. In Reptiles generally the articular extremities of the long bones are not very definitely sculptured, and do not manifest that reciprocal adaptation of their inequalities which are observed in the joints of Mammals and Birds. The difficulty of determining the coadapted extremities of detached bones of Reptiles is increased by the great thickness of the cartilage which covers them and renders their mutual contact more intimate, and which is always wanting in fossil bones. The Pterosaurian modification is, however, purely adaptive; and the relation to Warm-blooded Vertebrates in this respect is one of analogy. An argument in favour of avian affinity from the joint-structures could only be propounded by one not gifted with the judgment needed to deal with problems of this nature.

The left femur (65′) preserves its natural articulation with the acetabulum; the head is bent forward from the line of the shaft for an extent like that at which the condyles are produced backward; the shaft is straight, the great trochanter is feebly developed. There is no evidence of a modification of the distal condyle for the interlocking articulation with the fibula, which in Birds relates to their bipedal station and walk. The length of this femur is 3 inches 4 lines

The left tibia (66′), bent back at an acute angle upon the femur, measures 4 inches 10 lines in length. There is no trace of patella, nor has this sesamoid bone been found in any Pterosaur. The inner side of the bone being exposed, the styliform rudiment of the fibula is hidden from view. The trochlear termination of the distal end of the tibia is better marked than in *Crocodilus*, or even than in *Scelidosaurus* ('Monograph on Oolitic Reptilia,' Part II (1863), p. 16, Pl. X, 66), and consequently approaches more nearly to the characteristic form of the joint in Birds. The resemblance to the bicondyloid termination of the femur is instructively shown in the distal portion of the Pterosaurian tibia figured in Pl. XIX, figs. 8 and 9, and in the distal half of the right tibia of *Dimorphodon*

[1] 'Ossemens Fossiles,' 4to, v, pt. ii, p. 371.

[2] Beiträge zur Kentniss verschiedener Reptilien der Vorwelt, in 'Nova Acta Acad. Natur. Curios.,' Leopold Carol., &c., 4to, tom. xv. "Reptilien aus dem lithographischen Schiefer, *Pterodactylus crassirostris*, nobis, tabs. VII—X."

[3] 'Bridgewater Treatise,' 8vo, 1836, pl. 22.

[4] Owen's 'Palæontology,' 8vo, 1861, fig. 97.

in the slab, Pl. XVIII, at 66, which crosses the right antibrachium (51, 55). The deflected posterior ends of the condyles are here shown, and beneath them three tarsal bones (*o*, *l*, *b*), with the characteristic short and thick metatarsal of the fifth toe (*m*, *v*).[1]

The tarsal bone between the tibial trochlea and the three metatarsals (*i*, *ii*, *iii*), answers to the astragalus, marked *a*, in *Scelidosaurus* and *Crocodilus* (Monograph and Plate above cited); two tarsals, of which the one representing the second row is the smallest, intervene between the tibia and the fifth metatarsal; the larger of these ossicles answers to the calcaneum (*l* in *Scelidosaurus* and *Crocodilus*, Monograph, *ut suprâ*), the smaller and distal one to the cuboides (*b*, *ib.*).

The bony frame-work of the left foot (69′) is instructively preserved; the first four metatarsals are, as usual, long and slender, and resemble those in previously described *Pterosauria*; their under or plantar surface is exposed. The metatarsal of the first or innermost toe (*i*) is the shortest, that of the fourth toe (*iv*) is next in length; the third (*iii*) is the longest, but there is little difference in this respect; their distal condyles project toward the sole, and are made trochlear by a mid-groove.

The innermost digit shows the proximal and ungual phalanges in natural connection with each other and with the metatarsal: the ungual phalanx (*i*) is scarcely half the size of that of the corresponding digit (*1*) of the fore-foot. The ungual phalanges of the three other toes (*ii*, *iii*, *iv*) are preserved, showing the usual uniformity of size in the hind-foot of *Pterosauria*: the number and disposition of the contiguous but scattered phalanges best accord with the phalangeal formula (3, 4, 5) presented by the second, third, and fourth toes respectively, in better preserved feet of other *Pterosauria* (Pl. XIX, fig. 5). There is, however, here unequivocal evidence of a fifth toe, and that not merely rudimental but recognisably functional though without a claw. The tarsal bones (*b*, *l*) support a metatarsal (*m*, *v*) directed parallel with the metatarsals (*i*—*iv*), but much shorter and also thicker: it is 6 lines in length, and expanded at both ends, the proximal one being $2\frac{1}{2}$ lines in breadth, the distal one 2 lines, and the middle of the shaft $1\frac{1}{2}$ line. The under or plantar side of the bone is exposed, as in the others, and shows a shallow oblique channel passing from the proximal end obliquely to the inner side of the shaft, dividing two elevations at that aspect of the proximal end. The distal end is a moderately convex condyle, the outer and plantar prominence of which is broken off. I regard this bone as the fifth metatarsal. It supports a digit of two phalanges: the first (1, *v*) is slightly dislocated, so as to show the concavity of its proximal joint close to the condyle to which it was articulated: it is 1 inch 3 lines in length, and is thicker as well as much longer than the corresponding phalanx of the other toes. The second phalanx (2, *v*) is 1 inch in length: it is bent back upon the first, and gradually tapers to a point. Both phalanges,

[1] This throws expository light on the idea, revived by Gegenbaur ('Vergleichend-anatomische Bemerkungen über das Fussskelet der Vögel,' in Reichert's 'Archiv für Anatomie, Physiologie, und wissensch. Medicin,' 1863, p. 445), viz., that the distal trochlear epiphysis of the Bird's tibia represents its proximal tarsal series, or astragalus.

in the specimen described, pass obliquely across and beneath the four long metatarsals supporting the unguiculate claws.[1]

From the position of this exunguiculate long and slender toe, as well as from its difference of structure, we may infer its application to a different office from that of the other toes. These obviously subserve the purposes of terrestrial locomotion, and perhaps of suspension: the fifth toe I infer to have helped to support, like the similarly shaped production of the calcaneum in certain Bats, the interfemoral expansion of alar integument, in the way indicated in the restoration (fig. 2, Pl. XX) of *Dimorphodon macronyx*. In the habitual mode of locomotion by vigorous act of flight this toe would be in action while the other four were at rest; hence the necessity for greater thickness and strength of its bones, and the size of one of the tendons, as indicated by the groove in the metatarsal. Interesting, also, is it to note the analogy of this 'wing-toe' with the 'wing-finger,' though they be not homotypes, as shown in the shortness as well as thickness of the metapodial bone and the length of the pointed, clawless, terminal phalanx.

The fourth slab of Lias adding to our means of reconstruction of *Dimorphodon*, was observed by the Earl of Enniskillen in the collection of Henry Marder, Esq., M.R.C.S., of Lyme Regis. It had been quarried from the same cliff as the preceding specimen (Pl. XVIII), and displayed the vertebræ and bone-tendons of a long and stiff tail (Pl. XIX, fig. 4).

Indications of such a tail, in which the vertebræ were associated with ossified tendons, were apparent, and have been noted in the description in the second specimen with the skull (Pl. XVIII, cd); whereby one was able to show that the vertebræ in the originally described specimen supposed to be cervical (Buckland, loc. cit., pl. xxvii, *a*, *a'*) were truly caudal, with similarly associated bone-tendons, as, indeed, *Von Meyer* had recognised after the discovery of the caudal structure of his *Ramphorhynchus*.[2] The specimen now to be described of the entire tail, as represented by its petrifiable parts (Pl. XIX, fig. 4)[3] I conclude, from the identity of character of some of its vertebræ with the three shown in Pl. XVIII, *c d'*, and from the discovery of this specimen in the same formation and locality, to belong to *Dimorphodon macronyx*.

The series of caudal vertebræ, to judge from the size of the anterior ones, comes from an individual as large as that represented by the fossils in Pls. XVII and XVIII, and, no doubt, from an adult or full grown one. This series is 1 foot 9 inches in length, following the curve,

[1] "Cuvier, Wagler, und Goldfuss lassen den Fuss aus fünf ausgebildeten Zehen bestehen; in allen Pterodactyln habe ich aber nie mehr als vier solchen Zehen und höchstens noch einen Stummel vorgefunden." Von Meyer, op. cit., p. 20. But see 'Ossemens fossiles,' 4to, tom. v, pt. ii, p. 374—"Le cinquième réduit à un léger vestige," &c.

[2] "Beiträge zur näheren Kenntniss fossiler Reptilien," in Leonhard und Bronn's 'Neues Jahrbuch für Mineralogie,' &c., 8vo, 1857, p. 536.

[3] It has been drawn with the neural aspect downward.

which is single and slight; and it includes upwards of thirty vertebræ. These vertebræ, 3 lines in length of centrum in the first five, progressively increase to a length of 1 inch at the twelfth, begin to shorten gradually after the fifteenth, the twenty-first being 11 lines, the twenty-fourth 9 lines, the twenty-eighth 6 lines, and the thirtieth 5 lines in length. In breadth or thickness the vertebræ decrease from the first to the tenth; and then again gradually from the fifteenth to the last, which is filiform.

The first caudal, or the first of the series here preserved, has the anterior articular surface of the centrum subconcave. The inferior surface describes a slight concavity lengthwise; the upper part of the anterior half projects as a parapophysis, the end of which has been broken off, showing the open cancellous structure. A ridge from its upper part was continued to the fore part of the anchylosed neural arch. This arch developed zygapophyses, of which the anterior extend beyond the centrum; but they are better shown in succeeding vertebræ.

In the second caudal the base of the parapophysis has receded and now projects from the upper part of the side of the centrum, occupying more than its middle third. Part of a quadrate spinous process is here preserved, projecting above the centrum as far as the vertical diameter of that element.

In the third caudal the base of the parapophysis, reduced in vertical thickness, occupies the same positions and longitudinal extent. The postzygapophysis, after a deep hind notch of the neurapophysis, curves over the prezygapophysis of the succeeding vertebra, which enters that notch.

In the fourth caudal the base of the parapophysis has lost in longitudinal as well as vertical extent, and is more posterior in position. The subconvexity of the hind articulation of the centrum is here well shown. The confluent neural arch is low, attached to rather more than the fore half of the centrum. The postzygapophysis does not extend back beyond the centrum; the prezygapophysis is continued beyond the front or concave surface of the centrum into the neural notch of the preceding vertebra.

In the fifth caudal the parapophysis is smaller and more posterior. The neurapophysis rises from the anterior half of the side of the centrum and continues to show the zygapophysis, though reduced in size. Between the fifth and sixth caudals a small, slender hæmapophysis (*h*) has been articulated to the under part of the intervertebral space.

The reduced parapophysis is continued from the sixth caudal; this vertebra shows a much reduced indication of neurapophysis. The base of a hæmapophysis crosses the lower part of the space or joint between it and the seventh caudal, then expands both forward and backward, and more so in the latter direction; the inferior border of this expansion is straight.

In the seventh caudal the prezygapophysis is still indicated, though much reduced in size. The hæmapophysis, similar in shape to the preceding one, is longer; and three bone-tendons rise from the side of the hind projection of this hæmal arch.

In the eighth caudal the base of a reduced parapophysis projects from the side of the centrum behind its middle; a low prezygapophysis projects from the neural arch: but beyond this vertebra all trace of that arch disappears, or is indicated by feeble prominences in the fasciculus of bone-tendons which seem to be attached to neural processes of the non-elongated centrums. Six or seven filamentary bone-tendons, one thicker than the rest, extend lengthwise above the centrum. Some of these may be traced over two centrums, then end in a point, their place being taken by another bone-tendon beginning by a similar pointed end. The parapophysis disappears in the tenth vertebra.

The caudal vertebræ in the first discovered specimen of *Dimorphodon*[1] answer to the eighth—eleventh in the present series. The elongate centrums of the tenth and succeeding caudals, usually more or less uncovered by the bone-tendons, show a low lateral ridge, and a slight expansion at the ends. The hæmapophyses are traceable, much reduced in size, to the fifteenth—sixteenth vertebræ. The bone-tendons are in two fasciculi, one neural, the other hæmal, in position. From five to eight may be counted in the side view given of each of these fasciculi. The seeming increase of thickness of some, usually the more peripheral of the filaments, may be due to this flattened form, and to more or less of the side coming into view, instead of the edge. Five or six may be counted in each fascicule, even beyond the twentieth caudal; the number varying at parts through the formation of the bundle by successive tendons, as above mentioned. They are reduced to two or three at the thirtieth vertebra. The terminal joints of the elongate centrums appear to be flattened and closely adapted, allowing of very little motion. It is evident that, as in *Rhamphorhynchus*, the tail was stiff as well as long, and doubtless served as a sustaining ray of the parachute of membrane continued backwards from the wings and hind limbs.

The vertical diameter of the second caudal showing its neural spine is five lines. The diameter of the ninth vertebra, including the neural and hæmal fasciculi of bone-tendons, is the same; and beyond this the vertebræ and their surroundings gradually diminish to the pointed end of the tail.

§ Restoration of Dimorphodon. Plate XX.

The several parts of the skeleton of *Dimorphodon* preserved in the slabs of Lias described and referred to in the foregoing pages have ultimately yielded the desired result of their scrutiny and comparison, viz., a restoration of the extinct animal, such as I have endeavoured to exemplify in Plate XX; and I propose to apply that plate in illustration of a summary of the osteology and dentition of *Dimorphodon*, comparing therewith the

[1] Buckland, loc. cit., pl. 29, *a*, *a*. I have had these vertebræ carefully redrawn, from the specimen, in Pl. XIX, fig. 3.

previously known *Pterosauria*, and adding such deductions as to the status and affinities of the order as seem legitimately to flow from the facts.

The first distinguishing feature of *Dimorphodon*, or of the present liassic type of the genus, is the disproportionate magnitude of the head—the more strangely disproportionate, as it seems, in an animal of flight.

The head is large in proportion to the trunk, not only in respect of length but of depth, and probably, also, breadth; nevertheless, the shape and disposition of the constituent bones are such that, perhaps, no other known skull of a vertebrate is constructed with more economy of material—with an arrangement and connection of bones more completely adapted to combine lightness with strength.

So far as the skulls of *Pterosauria* have been sufficiently entire to show the shape of the head, no other known species resembles *Dimorphodon*. The cranial part is singularly small: the rest is mainly devoted to the formation of the large, long, and powerful prehensile and manducatory jaws. Among the débris of the cranial bones, in specimens Pls. XVII and XVIII, the mastoid (8), parts of the occipital (paroccipital, 4), the parietal (7), post-frontal (12), frontal (11), prefrontal (14), and nasal (15), are recognisable: the last two bones, however, are concerned more with the scaffolding or buttressing of the upper jaw than with the protection of the brain or formation of its case. Though contributing their shares to the otocrane, the chief developments of the paroccipital (Pl. XX, 4) and mastoid (ib. 8) relate to the muscular connections of the head with the trunk: the mastoid joins the postfrontal to form an upper zygoma, giving origin to part of the temporal muscles; it also affords a fixed articulation to the tympanic, and sends down a pointed process external to the masto-tympanic articulation. The parietals (Pl. XX, 7), confluent at the mid line, where they develop a low crest, swell out slightly at the temporal fossa, indicative of the size and saurian position of the mesencephalon. The frontal (11) is narrow and flat between the orbits, of which it contributes most of the upper part of the rim. This is continued by the postfrontal (12) behind, which sends down a long pointed process to unite with the malar (26), and a shorter and thicker one to join the mastoid (8). The prefrontal (14), of a triangular form, contributes to the upper and fore part of the orbit, and, either directly or by a connate lacrymal, unites with the ascending malo-maxillary process (21, 26), and the base of the prefrontal articulates with the frontal and the nasal. The nasals (15), to the usual connections with the frontal, prefrontal, and medial process of the premaxillary (22^{a}), superadd a union with the lateral ascending process of the maxillary (21^{a}), completing the bar between the nostril (*n*) and the antorbital vacuity (*a*). The nasal bone forms the upper part of the nostril; the rest of the boundary of that singularly wide aperture is formed by the premaxillary and maxillary. Of the basis cranii and palate there do not appear to be any recognisable parts preserved. The maxillary is overlapped by the hind alveolar part of the premaxillary, and unites therewith by a long oblique suture (21^{a}). The maxillary, receding, expands and sends upward a long slender pointed process to articulate

with the nasal; it then joins the malar and the prefronto-lacrymal, and descends internal to the mandible to join the palatine.[1] Each maxillary (21, 21′) affords alveoli for eight or nine teeth.

The premaxillary is the largest of the bones of the head. The pair, by confluence or connation, constitute the fore part of the upper jaw (22), expanding from a sub-obtuse apex as it recedes, and preserving its entireness for an extent of about two inches. This tract seems to be arched above transversely, with a slightly convex upper longitudinal contour continued along the medial ray or process (22′). Of the configuration of the palatal surface the specimens give no evidence. From the analogy of *Pterodactylus Cuvieri* and *Pt. Sedgwickii*,[2] we may infer that this (premaxillary) part of the bony roof of the mouth was entire, and strengthened by a median ridge. The lateral or alveolar borders formed alveoli for four teeth on each side. Thus the hind expansion of the premaxillary divides into three rays or processes. The upper medial or nasal ray is the longest: it is continued backward, continuing the initial curve of the upper contour of the face as far as the nasals, the mid suture or confluence of which bones it overlaps, and joins suturally to an extent precluding any movement of the upper jaw on that part of the head. The length of this ray is about $3\frac{1}{2}$ inches. The pair of lower or alveolar rays extend back for about $1\frac{1}{2}$ inches.

The malar (26) forms the lower narrower end of the oval orbit, sending up one pointed process (united with that of the maxillary ?) toward the prefrontal, and a longer and stronger one to join the postfrontal. The squamosal (27) continues the zygomatic bar backward to abut against the tympanic. Its precise position and direction are left doubtful in the specimens hitherto obtained, but it is unquestionably present, and contributes to the fixation of the tympanic.

This (28) is a moderately long and strong pedicle, immovably articulated to the mastoid, paroccipital, and squamosal; thickest posteriorly, where it is strengthened by an outer marginal ridge, sending forward and inward a process which may articulate with the pterygoid (but of this I could not get clear evidence), expanding at its distal end to receive the abutment of the squamosal or lower zygoma, and to form the convex condyle for the articular element of the mandible.

The dentary parts of the mandible are confluent at the symphysis, which is as long as the undivided fore part of the premaxillary. The ramal part of the dentary is compressed, and gains a depth of about 10 lines before it bifurcates. The alveolar border of the dentary extends as far as that of the maxillary, viz. about 5 inches, beyond which the upper prong (Pl. XX, 32′) is continued above the mandibular vacuity, underlapping the surangular (29) and terminating in a point. The lower prong (ib. 32″) terminates in a point before attaining the vacuity; it is underlapped by the fore part of the angular (30), with which it articulates.

[1] This description is on a homological hypothesis, subsequently discussed (p. 64).

[2] 'Monograph on Cretaceous Pterosauria,' Suppl. 1, 4to, 1859, Pl. I, fig. 1, *b*.

The divergence of the hinder prongs of the dentary exposes a small part of the splenial (31). The vacuity, if it be natural and not due to abrasion of a thin outer wall, is a long and narrow oval, 1 inch 8 lines in length, 6 lines in breadth. It is circumscribed behind by the confluent angular and surangular elements (29). The angular (30) forms a slight projection behind the articular concavity; it expands vertically, and contracts transversely as it advances, contributing a small share to the lower border of the vacuity, and contracting to a point below the dentary, about 5 inches from the angular process.

The range of variety shown by the skull is considerable in the order *Pterosauria*. In relative size, as in the expanse of the antorbital vacuity, *Pterodactylus crassirostris*[1] comes nearest to *Dimorphodon;* but the orbit is relatively larger, and the nostril much smaller. In *Rhamphorhynchus Gemmingi* the nostril and antorbital vacuity are of equal size, and each is about one eighth the size of the orbit, which is proportionally larger than in *Dimorphodon*. In *Pterodactylus longirostris*[2] the nostril is larger than the orbit; the antorbital vacuity is not half the size of the orbit. In *Pterodactylus suevicus*[3] the antorbital vacuity is still smaller. In *Pterodactylus Kochii*[4] that vacuity is limited, as in *Chlamydosaurus*, to the upper part of the boundary between the large orbit and the long and large nostril. In *Pterodactylus longicollum*[5] it appears to be wanting.

The shape of the skull offers many modifications in the several species, from the long and slender type of that of *Pterodactylus scolopaciceps* and *Pt. longirostris* to the shorter and deeper cone indicated by *Pt. conirostris*,[6] and to the inflated and more or less anteriorly obtuse form exhibited by *Dimorphodon* and the more gigantic *Pterodactylus simus*.[7]

The position of the tympanic pedicle varies from the almost vertical one in *Dimorphodon* to the almost horizontal one in *Pterodactylus longirostris* and *Pt. Kochii*. In *Pt. crassirostris* it shows an intermediate slope or position.

The mandible, conforming in relative depth and length to the general shape of the skull, has the symphysis longest in those species with long and slender jaws. In *Pterodactylus suevicus* the symphysis extends along the anterior third part of the mandible. In *Pt. crassirostris* it is shorter, and still shorter in *Dimorphodon*. The depth of the rami decreases behind the dentigerous part in *Pterodactylus longirostris*.

The generic dental character of *Dimorphodon* has been given in detail in the special descriptions of the specimens figured in Pls. XVII and XVIII. The range of variety mani-

[1] 'Monograph on Fossil Reptilia of the Cretaceous Formations' (1851), *Pterosauria*, Pl. XXVII, figs. 2—4.

[2] Ib., ib., fig. 1.

[3] Quenstedt, op. cit.

[4] Von Meyer, op. cit., tab. i, fig. 2.

[5] Ib., ib., tab. vii, figs. 1—4.

[6] Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, 4to, 1846, Pl. 38.

[7] 'Monograph on Fossil Reptilia of the Cretaceous Formations' (*Pterosauria*), Suppl. No. 3 (1861), Pl. I, figs. 1—3.

fested in this character is considerable in the present order, although in no species has any departure been observed from the predatory zoophagous condition. The teeth, always simple and pointed, vary in shape, in number, in position, in relative size. *Pterodactylus crassirostris* exemplifies the laniariform type of teeth, more or less elongate, and separated by intervals of varying extent. In this not uncommon condition the teeth are longest in the upper jaw, as offering more resistance than does the lower jaw in aid of the weapons most deeply implanted in the struggling prey.

In *Pterodactylus longirostris* the teeth are rather small, subequal, with short intervals, a little widening toward the hind end of the series, which is restricted to the anterior half of the jaw, both above and below.

In some *Pterosauria* a certain extent of the fore part of both upper and under jaws is edentulous, and from its shape has been inferred to have supported a horny sheath. The teeth are long slender canines, with wide intervals. They number from about 8 to 10 on each side of the upper jaw, and from 7 to 8 in each ramus of the mandible. Von Meyer proposed for this modification of mouth the generic name *Rhamphorhynchus*.

Dimorphodon shows the combination of scattered laniaries, with small, more closely set serial teeth in the lower jaw; it has more numerous teeth, occupying a greater extent of the alveolar margins of the jaws, than in any other Pterosaurian.

The very small teeth which have been observed in the short jaws of the little *Pterodactylus brevirostris*[1] are most probably characters of immaturity, not of species.

In regard to the bony structure of the head and the dentition, the general result of observation and comparison of Pterosaurian fossils, and common consent of competent investigators, having excluded the volant Mammals from the claim of affinity, the question becomes narrowed to whether the skull in *Pterosauria* more resembles that in the cold-blooded or the warm-blooded oviparous air-breathing Vertebrates.

Hermann von Meyer, who has contributed a great and valuable share to our knowledge of the Pterosaurian order,[2] quoting Oken's opinion, "that the skull is intermediate in character between that of the Chameleon and Crocodile," sums up his own conclusions on that head in the following terms:—"The skull of *Pterodactylus* is essentially comparable only with that of Birds and Saurians. The preponderating resemblance with the Bird's skull cannot be contested. Against this, however, is a remarkable dissimilarity in certain parts which, on the other hand, approximates it to the type of Saurians."[3]

The term *Sauria* is here used in the sense of Brongniart and Cuvier, and it is open

[1] Goldfuss, loc. cit., tab. x, fig. 2.

[2] Especially in the admirable summary of his own and others' researches, in the part of his great work, 'Zur Fauna der Vorwelt' relating to "Reptilien aus dem lithographischen Schiefer," &c., fol., 1860.

[3] "Der Schädel der Pterodactyln, der nach Oken zwischen Chamäleon und Crocodil stehen würde, lässt sich eigentlich nur mit den Vögeln und den Sauriern vergleichen; die überwiegende Aehnlichkeit mit dem Vogelkopfe kann nicht bestritten werden; ihr gegenüber steht aber eine auffallende Unähnlichkeit in gewissen Theilen, die dafür zum Zypus der Saurier hinneigen."—Op. cit., p. 15.

to the unbiassed investigator, and, indeed, becomes plainly his business, to determine, not merely whether Avian or Saurian characters predominate in the Pterosaurian skull, but to define the degree of affinity or correspondence of cranial structure therein traceable to such structures in *Enaliosauria*, *Dinosauria*, *Dicynodontia*, *Crocodilia*, *Lacertilia*, each of which may be a group, organically, of co-ordinate value with *Aves*.

Greater respect to the memory of so unbiassed a seeker after truth cannot be shown than by weighing with due care and what judgment one may be able to bring to the task the value and significance of each well-determined evidence of the cranial structure which Von Meyer has described and reasoned upon.

It is to be regretted that not in any of the numerous figures of the skull of *Pterosauria*, original or copied, has Von Meyer indicated the bones which he describes. When he writes—"The temporal bone lies external to the parietal and principal frontal bones, and mainly forms the temporal fossa,"[1] one much wishes he had indicated his 'Schläfenbein' in the skull of *Rhamphorhynchus Gemmingi*, pl. iii, fig. 4; pl. ix; pl. x, fig. 1; or in the more instructive example of cranial structure which he has borrowed from Goldfuss for the subject of his pl. v (*Pterodactylus crassirostris*).

By 'Schläfenbein' Von Meyer may mean that element of the compound 'temporal bone' of anthropotomy which I have called 'squamosal.' No doubt in Man and most Mammals the squamosal does contribute a notable share to the formation of the temporal fossa, whence the name 'temporal' given to the incongruous group of cranial elements coalescing in such warm-blooded Vertebrates with the squamosal, so exceptionally expanded in the *Mammalia*. But as to the value of the bed of the temporal muscles in determining the homology of the bones forming it, I would refer to the remarks in my work on the 'Homologies of the Vertebrate Skeleton.'[2]

Some clue to the bone signified by Von Meyer may be got from the following remarks—"Anteriorly it seems not to take, as in Birds, a share in the formation of the orbital rim; here, much more as in Saurians, it is pushed aside or supplanted by the postfrontal."[3]

The term 'temporal bone' (Schläfenbein) has been used in various senses, but whether it be applied to that element which I, with Cuvier, call 'mastoid' in *Reptilia*, or to that which others,[4] with Cuvier, call 'temporal' (meaning squamosal) in Birds, there is no bone that Von Meyer can be supposed to mean by 'Schläfenbein' which forms any part of the rim of the orbit in Birds.

Von Meyer recognises a 'postfrontal' ('Hinterstirnbein') in *Pterosauria*, and states that it pushes away his temporal (Schläfenbein) from the orbit. In *Pterosauria* the post-

[1] "Das Schläfenbein liegt aussen an dem Scheitelbein und Hauptstirnbein, und bildet hauptsächlich die Schläfengrube."—Op. cit., p. 15.

[2] 8vo, 1848, p. 33.

[3] "Vorn scheint es nicht wie in den Vögeln an der Bildung des Augenhöhlenrandes Theil zu nehmen, hier vielmehr wie in den Sauriern durch das Hinterstirnbein verdrängt zu werden."—Op. cit. p. 15.

[4] Hallman, "Die vergleichende Osteologie des Schläfenbeins," p. 8, pl. 1.

frontal (Pl. XX, 12) is undoubtedly interposed between the bone I determine as 'mastoid' (ib. 8) and the orbit (ib. *o*); and my 'mastoid' in *Pterosauria* answers to Cuvier's and Hallman's 'temporal,' *i.e.* squamosal, in Birds. We may conclude, therefore, that Von Meyer's 'Schläfenbein' in *Pterosauria* is that marked 8 in the skull of *Pterodactylus crassirostris*.[1]

Certain it is that no bone answering to 8 in Pls. XVII, XVIII, XX of the present Monograph contributes to the formation of the orbit in any Bird. In the great majority of that class, as is well known, the rim of the orbit is incomplete below; it is formed above by the frontal, before by the prefrontal and lacrymal ('antorbital' of ornithotomists), behind by the postfrontal ('postorbital,' ib.). Where, as in some *Psittacidæ*,[2] the orbital rim ('Augenhöhlenrandes') is complete, the lower complement is formed by an extension of ossification from the antorbital to the postorbital processes, independently of either Cuvier's temporal (8) or my squamosal (27) in Birds.

I confess that the foregoing result of the analysis of a main ground of Von Meyer's assertion as to the "incontestable similarity between the Pterosaurian and Avian types of cranial structure" has not a little tended to shake my confidence in the grounds on which he has pronounced definite judgment on the matter. So far as we have yet got evidence of the structure of the skull in *Pterosauria*, it seems that, contrary to the rule in Birds, the orbital rim is entire; and that its lower border is completed by the zygomatic arch, and chiefly, if not exclusively, by the malar element; whereas, such arch passes freely beneath the orbital rim in the few Birds with that rim entire. Now, in this part of the cranial structure the *Pterosauria* agree with the *Crocodilia*: as in them the malar (26) sends up a process to unite with one descending from the postfrontal (12) to complete the orbital rim behind.

In the small species of Pterodactyles (*Pt. longirostris*, *Pt. scolopaciceps*, and in the perhaps immature animal represented by *Pt. brevirostris*) the hind convexity of the cranial wall is not marked by the apophysiary developments of paroccipital and mastoid, and accordingly resembles that part of the cranium in Birds, especially the smaller *Grallæ*; but before this similarity of shape can be pressed into the argument for the Avian affinity of the *Pterosauria*, it should be shown to be common to or constant in the extinct volant order.

But this is far from being the case. When a Pterosaur has gained the size of *Pterodactylus crassirostris*[3] or *Pter. suevicus*,[4] the back of the skull shows no cerebral swelling, but only the crests and processes for muscular attachments, as in other *Reptilia*

[1] 'Monograph on Fossil Reptilia of the Cretaceous Formations' (*Pterosauria*) (1851),' Pl. XXVII, figs. 3 and 4.

[2] 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, pl. i, fig. 1 (*Calyptorhynchus*); 'Anatomy of Vertebrates,' 8vo, vol. ii (1866), p. 51, fig. 30 (*Psittacus*), also p. 63.

[3] Goldfuss, op. cit., pl. vii.

[4] Quenstedt, op. cit.

of similar size. Even in *Rhamphorhynchus Gemmingi* the cranial convexity is not posterior, but is limited to the temporal fossæ behind the orbit, as in the specimen figured by Von Meyer in pl. ix, op. cit.; and this indication of the optic lobes is less conspicuous in the subject of pl. x, fig. 1. In *Dimorphodon* there is still less trace of this alleged Avian characteristic.

The bone which, in the Bird, as in the Pterosaur, forms part of the otocrane, articulates with the ex- and par-occipitals behind, with the alisphenoid in front, with the parietal above, and with the petrosal within, which contributes the articular surface to the tympanic and the upper rim to the meatus auditorius, also articulates in the Pterosaur, as in the Crocodile, with the postfrontal: and this character appears to be constant in the *Pterosauria* as in the *Crocodilia*, while it is exceptional in *Aves*. In the particulars in which the bone 8 differs in the *Pterosaurian* from that in the Bird, it agrees with 8 in *Crocodilia*; as *e.g.* in its high position in the cranium, owing to the low development of the cranial chamber; its greater degree of projection from the true cranial walls; the extensive and suturally fixed character of its articulation with the tympanic as compared with the more definite and restricted glenoidal movable articulation which the mastoid (8) affords to 28 in Birds. In all these circumstances, whether the bone 8 (Pl. XX, fig. 1) be called mastoid or squamosal, it is Reptilian, not Avian, in the Pterosaur.

Herr Von Meyer states, in another of his comparisons, that in the *Monitor*, *Iguana*, and *Stellio*, the prefrontal ('Vorderstirnbein') enters into the formation of the periphery of the external nostril (Nasenloch).[1] This is the case with *Varanus*,[2] not with true Monitors.[3] In *Tejus nigropunctatus* some extent of the suture between the nasal and the maxillary intervenes between the prefrontal and the nostril. The non-extension of the prefrontal to the external nostril shows no Avian affinity in *Pterosauria*; rather an agreement with the majority of *Reptilia*, as, for example, with the whole order of *Crocodilia*.

In some *Crocodilia* (*Teleosaurus*) and *Lacertilia* (*Chlamydosaurus*, *Lyriocephalus*) there is an antorbital vacuity, which, in the latter Lizard (Pl. XX, fig. 3, *a*), is equal in size with the nostril (ib., *n*) and intermediate in position between that cavity and the orbit (ib., *o*), which is large. A process of the maxillary rises obliquely backward to join the nasal, and to separate the intermediate vacuity from the external nostril. The lacrymal and prefrontal form the bar dividing the intermediate cavities from the orbit. In most Birds a small intermediate vacuity is partitioned off from the nostril by a process of the maxillary rising to join the nasal, and is similarly separated from the orbit by the lacrymal, which descends to join the malar. The great range of variety in the development of this 'intermediate' or 'antorbital vacuity,' in *Pterosauria*, has already been pointed out; but

[1] 'Zur Fauna der Vorwelt,' fol., 1860, p. 16.

[2] See Cuvier, 'Ossemens fossiles,' v, pt. 2, pl. xvi, fig. 1 ('grand Monitor du Nil, *Lacerta nilotica*'), p. 259, the *Varanus Dracæna* of Merrem, *Varanus niloticus* of most modern erpetologists; also in pl. xvi, fig. 7, 'Monitor du Java,' p. 260; the *Varanus bivittatus*, of Merrem.

[3] As *e.g. Tupinambis teguixin*, 'Sauve-garde d'Amérique.' Cuvier, vol. cit., pl. xvi, figs. 10, 11, and *Thorictes Dracæna*, ib., figs. 12, 13; 'La Dragone,' ib., p. 263.

the comparable structure is by no means peculiar, as Von Meyer would lead one to infer, to the skulls of Birds.[1]

In no Pterosaurian has any obvious and unmistakeable suture been seen indicative of the respective shares taken by maxillary (21) and premaxillary (22) in the formation of the dentigerous part of the upper jaw: both bones combine to support the array of teeth; they have coalesced, at least at their external or faci-alveolar plates; as, likewise, have the right and left premaxillary portions forming the fore end of the upper jaw. The suture between this premaxillo-maxillary bone and the suborbital portion of the zygomatic arch remains. Accordingly, there is a choice of analogies in the interpretation of the observed facts: a proportion of the compound bone may be assigned to the premaxillary, according to the analogy of the Crocodile and Lizard; or the whole may be called premaxillary, according to the analogy of the Ichthyosaur.

Goldfuss, guided by the Lacertian analogy, limits the premaxillary to the anterior part of the upper jaw, and to the upper part of the external bony nostril (*n*); and he illustrates this view by a dotted line representing the assumed suture in his restoration of *Pterodactylus crassirostris*, in pl. ix (op. cit.).[2] Von Meyer assumes, as arbitrarily, the Ichthyosaurian analogy, but views it as a specially Avian one, and ascribes to the *Pterosauria* a bird-like premaxillary,[3] and this determination is indicated by the numerals on the restoration of the skull of *Pterodactylus compressirostris* in my Monograph of 1851, quoted below, Pl. XXVII, fig. 5.

Of the maxillary bone (my 21) Von Meyer merely remarks that "it does not follow the type of Birds" ("folgen nicht dem Typus der Vögel," ib., p. 15). And yet, if the Pterosaurian premaxillary be interpreted according to that type, forming so large a proportion of the upper jaw as to include all the teeth, the edentulous maxillary must have had a correspondingly Avian proportion and position. Only, whereas in most Birds the small and slender maxillary sends up a process helping to define the back part of the nostril and fore part of the antorbital vacuity, the corresponding process in *Pterosauria* would be (as indicated in my Pl. XVIII, 22^x), part of the premaxillary.

I incline to believe, however, that it may prove to belong to the maxillary; that the dentigerous part of the upper jaw is due, in *Pterosauria*, to the combined maxillaries and premaxillaries, but that the latter take a larger share in the formation of the alveolar tract than Goldfuss conjectures. One ground of such opinion is this: the portion of upper jaw with six pairs of laniary teeth in the huge *Pterodactylus Sedgwickii*, in which the palatal surface could be clearly worked out,[4] showed that the anterior expansion, with the group of three pairs of teeth, could hardly have been

[1] "Zwischen Nasenloch und Augenhöhle liegt eine dritte Oeffnung, die wiederum an den Vögelschädel erinnert."—Op. cit., p. 16.

[2] Copied in Pl. XXVII, fig. 4, of my Monograph above cited of 1851.

[3] "Ein Vögeln-ähnlichen Zwischenkiefers," v, p. 15, op. cit.

[4] Monograph, Suppl. No. 1 (1859), Pl. I, figs. 1, *a*, *b*.

separated by a suture, at the slight constriction suggesting that structure in *Pt. crassirostris*,[1] without leaving some indication of its original existence, especially on the palate.

In the anterior confluence of right and left premaxillaries, and the backward production from their upper part of a bony bar uniting with the nasals and dividing the nostrils, we have a character of the Dicynodonts and of some Lacertians (*Varanus*) as well as of Birds, and the Saurian affinity is shown to be the truer one by the firmness of the naso-premaxillary union and the absence of any power of, or provision for, that hinge-like movement of the upper mandible upon the cranium which is peculiar to, though not constant in, the Avian class. Moreover, the outer surface of the premaxillary shows none of that spongy porosity and rugosity which relates to the sheath or horny covering of the beak characteristic of the Bird. Such structure has not even been detected in the feeble trace of edentulous anterior production of the upper jaw in *Rhamphorhynchus*, Von Meyer. I cannot, therefore, see, with Von Meyer, the beak of the Bird in an animal with a fixed and toothed upper jaw ;[2] for on every hypothesis of its bony structure it finds a closer resemblance among the toothed Reptiles than in the class of Birds.

The mandible, or lower jaw, is supported, as in all Vertebrates below Mammals, by the tympanic, viz. the bone (28, Pls. XVIII and XX) which is shown by its osseous connections, its relations to the 'facial nerve,'[3] or its equivalent the 'ramus opercularis,'[4] and by its mode of formation, to answer to that which in Mammals is mainly reduced to the function of supporting the ear-drum. In air-breathing Ovipara it superadds this function to its more constant and essential use in non-mammalian Vertebrates, of supporting the lower jaw.

In reference to the question of affinity before us, the tympanic gives valuable evidence by reason of the moveable articulation and peculiar connections with the upper mandible essentially correlated to a covering of feathers. In *Pterosauria* the tympanic at its proximal end resembles that of Lizards by its fixed sutural mode of union with the cranium, and it furthermore resembles that in Crocodiles by the abutment of the zygoma against its distal end, to which it is suturally attached.

In Birds the tympanic enjoys a synovial moveable articulation by a single or double condyle at its proximal or cranial end, and presents a synovial cavity to a condyloid convexity of the hind part of the zygoma. By this test, therefore, the *Pterosauria* are shown to be not only 'Saurian,' but to be nearest akin to the existing orders which possess double-jointed ribs and the correlated cardiac structure. The difference of shape between the tympanic of the Pterodactyle and that of the Bird is too strongly marked not to have attracted attention; but I do not find in that of the Chameleon the

[1] Goldfuss, loc. cit.

[2] "Wir sehen also hier die Schnautze der Vögel auf ein Thier mit unbeweglicher und mit Zähnen bewaffneten Schnautze angewendet."—Op. cit., p. 15.

[3] 'Anatomy of Vertebrates,' vol. ii, 8vo, 1866, p. 124, vol. iii, p. 155.

[4] Ib., vol. i, p. 303.

most resemblance to the *Pterosaurian* tympanic.[1] For, besides the Lacertian freedom of the bone from zygomatic abutment, the tympanic in the Chameleon has not the longitudinal strengthening ridges, nor the process turned toward the pterygoid.

The dentigerous mandible, like the maxilla, speaks for the Reptilian affinity of *Pterosauria;* the distinct sockets for the teeth ally them to the higher forms of *Sauria.* In reference to the generic modification of dentition in *Dimorphodon*, it has been remarked that this early form of flying dragon seemed to have derived one feature or modification from the Fish, and the other from the Crocodile or Plesiosaur.[2]

The length of the neck, which is not always equal to that of the head, is due, in *Pterosauria*, rather to the length than the number of the vertebræ. Counting the axis with the small coalesced atlas[3] as one, I give seven cervical vertebræ to the *Dimorphodon macronyx* (Pl. XX, fig. 1, c). Of these a series of four are preserved in the specimen (Pl. XVIII, c), showing, as described, the characteristics of the Pterosaurian cervical vertebræ which had been determined and illustrated in a former Monograph.[4]

Cuvier,[5] in his searching analysis of the evidence at his command of the osseous structure of the *Pterodactylus longirostris*, concluded that the cervical vertebræ were not fewer than seven, as in *Crocodilia* and *Mammalia*, or not more than eight, as in *Chelonia.*

Goldfuss was able to demonstrate the vertebral formula in his famous specimen of *Pterodactylus crassirostris.*[6] The number, 'seven,' was, however, obtained by reckoning the atlas distinct from the axis, and the last cervical may have been relegated to the dorsal series.

Quenstedt[7] shows seven cervicals in his instructive example of *Pterodactylus suevicus*, reckoning the atlas and axis as one vertebra; and this analogy I have followed in the restoration of *Dimorphodon.*

Rhamphorhynchus Gemmingi has six cervicals, counting the coalesced atlas and axis as one; but in the specimen figured by Von Meyer in his pl. ix,[8] there seems to be the centrum of a short 'seventh' cervical between the longer 'sixth' and the first (dorsal) vertebra supporting a long free pointed rib. It is certain that the number of cervicals does not exceed the latter reckoning or fall short of the first. Thus it is plain that the *Pterosauria* exemplify the Crocodilian affinity in the cervical region of the vertebral column. Lacer-

[1] "Dieser Knochen ist nicht wie in den Vögeln quadratisch, sondern cylindrisch stielförmig beschaffem.—Hierin, so wie in einingen andern Theilen, zeigt das Thier die meiste Aehnlichkeit mit *Chamaeleon.*"—Von Meyer, op. cit., p. 16.

[2] 'Report (Sections) of the British Association for the Advancement of Science,' 8vo, 1858, p. 98.

[3] 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' Supplement, No. I, *Pterosauria* (1859), pp. 7—8, Pl. I, figs. 11—14.

[4] Ib., p. 9—11, Pl. II. 'Monograph,' &c., Supplement, No. III (1860), p. 7, Pl. II, figs. 1, 2 and 4.

[5] 'Ossemens fossiles,' tom. cit., p. 367.

[6] "Man zählt 7 Halswirbel, 15 Rippenwirbel, 2 Lenden, and 2 Kreuzbeinwirbel," loc. cit., p. 79.

[7] Op. cit., figs. 1—7.

[8] Op. cit.

tians have fewer definite cervicals ; Birds have more. I have not seen any Bird with fewer than eleven cervicals.[1] The length and flexibility of the neck is correlated with the covering necessitated by the high temperature of the Bird.[2] The cold-blooded flying Reptiles have a comparatively short and rigid neck, but of a thickness and strength proportionate to the size of the head, and adequate to the work to be performed by the jaws in overcoming and bearing away the prey they may have seized.

The chief variety manifested by the *Pterosauria* in the cervical region is in the relative length of the last six vertebræ ; this is greatest in *Pterodactylus longicollum* and *Pt. longirostris ;* it is least in *Pt. crassirostris* and *Dimorphodon macronyx*, and apparently also in *Pterodactylus simus*, if we may judge by the breadth, compared with the length, of the vertebra figured in Pl. XVIII, (figs. 1 and 2) of my Monograph, above cited, of 1860.

There seems to have prevailed a greater range of variety in the number of vertebræ between the cervical series and the sacrum. In *Pterodactylus longirostris*, Cuvier estimated at least twelve which supported moveable ribs,[3] and nineteen or twenty in the dorso-lumbar series. Von Meyer concluded that the number of dorsal vertebræ fell not below twelve in any species, nor exceeded fifteen or sixteen in *Pterosauria*. *Pterodactylus Kochii* shows fourteen dorsal vertebræ ; *Pt. crassirostris* not more than twelve, reckoned by the number of pairs of free ribs, which can be satisfactorily discerned.

I have seen no specimen of *Dimorphodon* yielding definitely the number of the dorso-lumbar vertebræ, *i. e.* of the vertebræ between the cervical and sacral ; it is from the best considerations I have been able to give to the analogies of these vertebral formulæ, in better preserved examples of other species of *Pterosauria*, that I assign thirteen to this series in my restoration of *Dimorphodon macronyx* (Pl. XX) ; and I conclude that the thirteenth was a true lumbar vertebra or without connection with a free pair of ribs. If there should prove to be error in this estimate I cannot think it will extend beyond one vertebra, or at most two, in excess of twelve dorsals.

The nine dorsal vertebræ, which have kept together, in almost a straight line, in the specimen (Pl. XVIII, D), testify to the strength and closeness of their reciprocal articulations, under disturbing influences which have affected so great and general a degree of dislocation of most other parts of the skeleton.

Buckland seems first to have observed the convexity of one of the terminal articular surfaces of the centrum of a dorsal vertebra, and to have deduced an affinity therefrom ;

[1] The Sparrow (*Pyrgita domestica*) has twelve ('Osteol. Catal. Coll. of Surgeons,' No. 1571, vol. i, p. 297).

[2] "As the prehensile functions of the hand are transferred to the beak, so those of the arm are performed by the neck of the Bird ; that portion of the spine is, therefore, composed of numerous, elongated, and freely moveable vertebræ, and is never so short or so rigid but that it can be made to apply the beak to the coccygeal oil-gland, and to every part of the body, for the purpose of oiling and cleansing the plumage." —'*Anat. of Vertebrates*,' ii, p. 39.

[3] Vol. cit., p. 368 :—"Il semble qu'il en est resté au moins douze en place du coté gauche." The specimen figured by Von Meyer, op. cit. in pl. i, fig. 1, shows thirteen ribs on the left side of the trunk.

(the specimen is marked *d* in the Plate 27 of his Memoir, loc. cit.), and is described "as the body of a vertebra showing a convex articulating surface, as in the Crocodile" (p. 221). Quenstedt's *Pterodactylus suevicus* showed similar detached dorsals, in one of which it appeared that "the articular surfaces of the body were convex at the back end, and concave at the fore part."[1] Buckland's specimen serves to dissipate any doubt on the point so important in reference to the Crocodilian affinity. It might be assumed that the Author viewed the convexity as posterior by the expression "as in the Crocodile;" and in the last of the dorso-lumbar series, which I regard, with Buckland, as 'probably lumbar,' in the sense of not being costigerous, the position of "its concave articulating surface" is demonstrated by those of the articular processes (zygapophyses) at the same end of the vertebra, which prove them to be the anterior pair, slightly prominent, looking upward and inward. Buckland notes these as "two anterior spinous processes, an obvious typographical error for 'oblique' or 'articular,' venial in one not professedly an anatomist.[2]

With regard to the Crocodilian affinity inferred from this structure, it must be remembered that the procœlian stucture, though it has been observed in Crocodiles from the Greensand of New Jersey,[3] is characteristic of the Tertiary and existing species, rather than of the order at large, which had more abundant and diversified (amphicœlian and opisthocœlian) representatives in the Secondary ages of Geology. Moreover, the anterior concavity and posterior convexity of the vertebral body obtain in most recent, Tertiary, and Cretaceous *Lacertilia;* and finally, the cup- and ball-joints of the centrum appear in the dorsal vertebræ of at least one genus of Birds, though with the ball in front.[4]

In the series of nine dorsals, preserved in the subject of Pl. XVIII, d, the centrums slightly lose length as they recede in position from the neck; the anterior ones measure 0·009 mm. = 4½ lines; the posterior ones measure 0·008 mm. = 4 lines; the transverse diameter of the articular ends is 0·007 mm. = 3 lines. The dorsal vertebra in Buckland's specimen presents the same dimensions. These dimensions increase as the two or three anterior dorsals approach the neck, but the greater enlargement of the last cervical is somewhat abrupt.

For the shape and proportions of the ribs (in the Restoration, Pl. XX), I have those marked *b*, *c* in the original specimen,[5] and the more numerous and better preserved ones

[1] "Die Gelenkfläche der Wirbelkörper war auf der Hinterseite convex, wie beim Crokodil, vorn dagegen concav. So scheint es wenigstens."—Quenstedt, Ueber *Pterodactylus suevicus* im lithographischen Schiefer Würtembergs. 4to, 1855, p. 45.

[2] Buckland, loc. cit., pl. 27. [This vertebra is shown in Pl. III, fig. 2, of the present Monograph.]

[3] "Notes on Remains of Fossil Reptiles discovered in the Greensand Formations of New Jersey," 'Quarterly Journal of the Geological Society,' vol. v, 1849, p. 388.

[4] As in *Aptenodytes;* "On the Vertebral Characters of the Order *Pterosauria*," 'Phil. Trans.,' 1849, pl. x, fig. 22, p. 163.

[5] Buckland, loc. cit., pl. 27.

in the specimen figured in Pl. XVIII. Their articulations with the vertebræ have already been noticed. The ribs increase in length to the fifth or sixth, with some diminution of breadth after the third, and acquire a characteristic tenuity beyond the sixth pair. On the outer surface a groove extends from the neck, or interspace between the head and tubercle downward; the front border of the groove being somewhat prominent, but subsiding in the hinder ribs. Epipleural appendages are indicated in some specimens; but the indications are feeble, and, if rightly so interpreted, these appendages seem to have been but partially ossified.

The sternal ribs, beyond the sternum, unite below with the free ends of the abdominal V-shaped, intermuscular styles.

The irregular elongate mass (marked 18 in pl. xxviii of Buckland's Memoir) and conjectured to be "sternum—much broken, and its form indistinct" (loc. cit., p. 221) includes two crushed cervical vertebræ, and part of a third. Of the sternum I have not been able to discern a satisfactory trace in any of the specimens of *Dimorphodon*; its proportions and position are, therefore, indicated in the 'restoration' (Pl. XX) according to the analogy of that in *Pterodactylus suevicus*,[1] *Pt. simus*,[2] and in *Rhamphorhynchus*.[3]

In the main, as regards breadth of the hind part and depth of the fore part, the breast-bone of *Pterosauria* is formed on the Ornithic pattern; *i. e.* it is shield-shaped, and it has a keel. But the keel does not descend from the expanded portion; it is formed, as shown in a former Monograph (Suppl. No. III, p. 8), by the vertical development of the anterior production answering to the ossified sternum of Crocodiles and to the episternum of Lizards. I would recommend a comparison of the figures of the sternum in *Iguana* and *Notornis*, given at p. 21, vol. iii, of my 'Anatomy of Vertebrates,' to whosoever may desire to form an opinion of the evidence of affinity to Birds or to Reptiles, respectively,

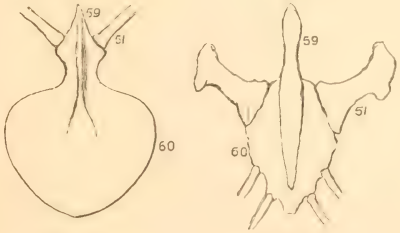


Fig. 1. Pterosaur.

Fig. 2. Crocodile.

afforded by the Pterosaurian sternum, especially as this is illustrated in figures 7 to 12 of Pl. II of the Supplement No. III, above cited. No one desirous of simply getting at the

[1] Quenstedt, loc. cit. (1855).

[2] 'Monograph,' Suppl., No. III (1860), Pl. II, figs. 7—12.

[3] Von Meyer, op. cit. (1860), pl. vii, figs. 1 and 3, and pl. ix, fig. 1.

truth of the matter can put aside the 'post-coracoid lateral emarginations,' and other modifications defined in that Monograph as 'distinctive Pterosaurian characters.' No Bird has shown any approach to them. What modifications of the Pterosaurian sternum *Dimorphodon* may have presented, we have yet to learn.

In all cases in which it has been observed, the sternum in *Pterosauria* (fig. 1) resembles in essential characters that of *Crocodilia* (fig. 2); its chief part is a longitudinal, compressed, deep bar (59), expanding laterally, some way from the fore-end, for the articulation of the coracoids (51),[1] and having the posterior expansion (60), which remains cartilaginous in the *Crocodilia*, more or less ossified, in the form of a thin semicircular plate: but the whole bone, though adaptively modified for attachment of muscles of flight, preserves the characteristic shortness compared with the trunk, and offers a striking contrast to the long and large subabdominal plastron in most birds of flight. There is no distinct T-shaped episternum, such as exists in most *Lacertia*, and no trace of clavicles as in Lizards and Birds. Distinct lateral elements for articulation with sternal ribs I have not satisfactorily made out in any specimen.

The abdominal hæmal arches consist of slender hæmapophyses and of chevron-shaped hæmal spines.

There is evidence of one lumbar or ribless vertebra anterior to the sacrum, in *Dimorphodon;* and no Pterosaurian appears to have shown more than two such vertebræ: in this character we are again directed to the true Reptilian relation of *Pterosauria*, and warned off the beguiling marks of Avian affinity.

The indications of epipleural appendages of ribs, more or less bony, if rightly interpreted, answer to the gristly ones in *Crocodilia* and some *Lacertia*.[2] The restoration of the bony cage of the thoracic-abdominal cavity of *Dimorphodon* (Pl. XX) is based on the analogy of better preserved specimens of *Pterosauria* in regard to this part of the skeleton. Scattered elements of the hæmal arches, 'abdominal ribs,' &c., have alone been met with in the specimens of *Dimorphodon* hitherto obtained.

The sacrum, on the probable hypothesis of retention of the length of centrum shown in the lumbar vertebra, would include at least four vertebræ; if, as by the analogy of the sacrum (figured in Pl. II, fig. 26, of the Monograph, &c., Supplement No. 1, 1859), the vertebræ lost length at this confluent tract, there might be five or six sacrals articulating with the iliac bones in *Dimorphodon*. Von Meyer figures 5—6 anchylosed sacral vertebræ in his *Pterodactylus dubius;*[3] and the sacrum appears to consist of at least six confluent vertebræ in *Rhamphorhynchus grandipelvis*, Von Meyer.[4]

With all the evidence that the *Pterosauria*, like the *Dinosauria* and *Dicynodontia*,

[1] 'Monograph on Cretaceous Reptilia,' Supplement, No. III (1860), Pl. II, figs. 7—12.

[2] As in *Hatteria*, see Günther's excellent Memoir, in 'Philos. Trans.,' Part II, 1867, p. 13, pl. ii, figs. 17, 24.

[3] Op. cit., p. 17, pl. vi, fig. 1.

[4] Op. cit., p. 53, pl. viii, fig. 1.

exceeded the sacral formula prevailing in existing *Crocodilia* and *Lacertilia*, we should gain no firm ground therefrom for predicating Avian affinity or for building thereon a derivative hypothesis of the class of Birds. Many existing Chelonian Reptiles have a sacrum composed of more than two vertebræ.[1]

The perfect specimen of tail-vertebræ and associated bone-tendons in the specimen (Pl. XIX, fig. 4) completes satisfactorily the restoration of this part of the vertebral column in *Dimorphodon*. Before the discovery of *Rhamphorhynchus*, the order *Pterosauria* was known only through species having the tail very short. Not only were the vertebræ comparatively few, estimated at twelve or thirteen in *Pterodactylus longirostris*,[2] at fourteen in *Pt. spectabilis*, at fifteen in *Pt. scolopaciceps*,[3] and as low as ten in *Pt. Meyeri*,[4] but they were very small and short. The great advocate of the Avian affinity of the Pterosaurs, Soemmerring, based his chief argument in this character. But Cuvier was able to adduce instances of *Reptilia* with tails as short; and he might now have cited a Bird with a tail-skeleton as long, as slender, and as many-jointed as in divers Saurians.[5] The earliest indication of a range of variety in this part of the bony framework of a Pterosaur was deduced, with his usual sagacity, by Buckland.

In the original specimen of *Dimorphodon* are three caudal vertebræ at the base of the tail, marked K, in pl. xxvii of his Memoir, from the size of which vertebræ, together with the larger and longer legs, as compared with *Pterodactylus longirostris*, Buckland inferred that the entire "tail was probably longer, and may have co-operated with the legs in expanding the membrane for flight."[6] "A long and powerful tail," he proceeds to remark, "is in strict conformity with the character of a Lizard" (ib.).[7]

Buckland would have had further direct confirmation of the length and strength of the tail of his Lias Pterosaur, if he had recognised the series preserved at *a*, *a'*, in his pl. xxvii, as caudal vertebræ; but they were conceived to belong to the neck, notwithstanding their slenderness and length, and that around them were "small cylindrical bony tendons, resembling the soft tendons that run parallel to the vertebræ in the tails of Rats."[8] When the evidences of caudal structure were first recognised by Von Meyer, in *Rhamphorhynchus Gemmingi*, he detected the homologous structures in pl. xxvii of

[1] 'Anat. of Vertebrates,' vol. i, p. 65.

[2] By Cuvier, vol. cit., p. 368.

[3] Von Meyer, op. cit., p. 17.

[4] Ib., p. 17.

[5] Owen "On the *Archæopteryx*," 'Philos. Trans.,' 1863, p. 33, pls. i—iv.

[6] Buckland, loc. cit., p. 221.

[7] *Archæopteryx* had not then been discovered; else, it might have been objected to the above hint of affinity, not only that there had been short-tailed Pterodactyles, but also long-tailed Birds.

[8] "Mr. Clift and Mr. Broderip have discovered that the remaining cervical vertebræ are surrounded with small cylindrical bony tendons of the size of a thread. These run parallel to the vertebræ, like the tendons that surround the tails of rats, and resemble the bony tendons that run along the back of the pigmy musk and of many birds" (loc. cit., p. 218).

Buckland's Memoir, and suggested that its subject might belong to the same section or genus.[1] The subsequent discovery of the skull and dentition has, however, shown that another generic section of *Pterosauria*, or at least one species thereof, had a similar long and stiff tail. The modification involving that quality does not, however, extend throughout; the anterior caudal vertebræ retain the more normal character, and the appendage would be most moveable at its base. No doubt a small degree of yielding at the many persistent vertebral joints—for complete anchylosis has not been observed—would allow a slight curvature to the extent to which the tail is represented as yielding to a lateral force in the restored figure (Pl. XX, fig. 2). The number of the caudal vertebræ in *Dimorphodon macronyx* was at least thirty; the termination of the specimen figured in Pl. XIX, fig. 4, does not indicate a loss there of as many centrums as would bring the number up to thirty-eight, which are assigned by Von Meyer to his *Rhamphorhynchus Gemmingi*.

As we cannot, therefore, with Soemmerring, insist on the shortness of the tail in some *Pterosauria* as proof that they were Birds, so neither can we conclude from the length of the tail in other *Pterosauria* that they were Reptiles. The legitimate taxonomic deduction from such caudal modifications is, that they are not of sufficient importance for determination of a class, and that they do not exclusively characterise the genus. They indicate adaptations in an extreme and variable part or appendage of the body to special powers or ways of movement, or sustentation, in air of the present group of volant animals.

So, likewise, it cannot be, as it has been, inferred from the length of tail in *Archæopteryx*, that it was a Reptile.[2] What we learn from that Avian fossil is akin to what we have learnt from Pterosaurian remains, viz., that the tail is a seat of extreme modification, in respect of length and number of joints, within the limits of the feathered class. Mammalogists, with a like drift, could add instructive evidence of corresponding caudal variability within the limits of the order, as in the volant *Cheiroptera*, and even within the bounds of the family (*Bradypus* and *Megatherium*, *e.g.*).

The value of the discovery of *Archæopteryx*, in relation to *Pterosauria*, is enhanced by the peculiar nature of the matrix, conservative of cutaneous as well as of osseous characters; showing casts of down and feathers,[3] impressions of the fine foldings or wrinkles of thin expansions of naked skin, as well as delicate tendons surrounding, working, strengthening, and stiffening the caudal framework.

With these parts the fine lithographic lime-marl should have preserved the plumose appendages of the long tail of *Rhamphorhynchus*, if that flying Reptile had possessed such; and, along with caudal plumes and vertebræ, should have been preserved the bone-tendons of the tail, if *Archæopteryx* had possessed that structure.

It is probable, from the constancy with which caudal vertebræ of long-tailed

[1] In 'Leonhard und Bronn's Neues Jahrbuch für Mineralogie,' &c., Jahrgang, 1857, p. 536.

[2] *E. g.*, as the *Gryphosaurus* of Andreas Wagner.

[3] A few of the delicate, downy body-feathers of *Archæopteryx* are clearly indicated near one side of the trunk in the slab with most of the bones of the specimen of *Archæopteryx* in the British Museum.

Pterosaurs have been found associated with their tendons,[1] that detached caudal vertebræ of *Archæopteryx* might be recognised through the want of them.

We may confidently conclude that the Oolitic mud which has entombed the greatest number and variety of the flying reptiles of its period would have shown us, when petrified into lithographic slate, their feathers, if, as warm-blooded animals, they had needed such heat-conserving a covering. The plumose clothing of the long-tailed bird of the period proves its hæmatothermal character, as the want of it shows the long-tailed pterosaur to have been cold-blooded.

The tyro, fresh from the lecture-room of his physiological teacher, ambitious of soaring into higher regions of biology than were opened to him at the medical school, impressed with the relations of active locomotion to generation of animal heat, may be pardoned for inferring that the amount of work involved in sustaining a Pterodactyle in the air would make it, physiologically, highly probable that it was a hot-blooded animal. But a competent friend, finding him bent on rushing with such show of knowledge into print, would counsel him to provide himself with a thermometer adapted to the delicate testing of the internal heat of small animals. So provided, if he should chance to beat down a chafer in full flight, the experiment, made with due care and defence of the fingers guiding the instrument, would teach him how fallacious would be the inference that, because an animal can fly, it must, therefore, be hot-blooded. Unless he happen, in introducing the bulb by the widened vent into the abdomen, to plunge it into a mass of ova, he will find the heat of the beetle, notwithstanding the amount of work involved in sustaining and propelling itself in air, not to exceed by more than one degree that of the atmosphere. If he has knocked down a female cockchafer prior to oviposition, the ovarian masses may indicate half a degree, or even one degree, higher of temperature (Fahr.). With the cooling of the air in the summer night the temperature of the *Melolontha* concurrently falls. So, likewise, would that of the flying reptile, whatever "amount of oxidation and evolution of waste products in the form of carbonic acid"[2] might have attended their exercise of flight. The constant correlative structure with hot-bloodedness is a non-conducting covering of the body. We may with certainty infer that *Archæopteryx* was hot-blooded, because it had feathers, not because it could fly.

There is no ground, from observation of the Sharks and Porpoises that accompany swift-sailing vessels, maintaining themselves near the surface, exercising their several and characteristic evolutions in quest or capture of prey, for inferring that the amount or the energy of muscular action is very different in the two surface-swimmers.

Sharks have and, no doubt, work a greater proportion of muscle than Cetaceans; a less proportion of their body is excavated into visceral cavities. Yet the Shark is cold-blooded; its temperature rises and falls with that of its medium; it has no provision, by

[1] As seen in Pl. II, at *cd*, and in Pl. III, figs. 3, 4, 5.

[2] 'Proceedings of the Zoological Society,' April, 1867, p. 417, Prof. Huxley "On the Classification of Birds."

a blanket of blubber or other superficial modification, in aid of the maintenance of a fixed and high degree of blood-heat.

There are conditions, it is true, in which a Reptile generates a higher degree of heat than is usual, but they are not those accompanying any unusual or excessive muscular work and waste; they are attended with rest, not locomotion. The incubating Boa gives to the hand that may be insinuated between the coils surrounding the eggs the sensation of a warm-blooded animal. Valenciennes[1] found, in the Reptile-house at the Jardin des Plantes, when its temperature, in the month of May, was 23° (Centigrade), that the heat of the *Python*, between the folds and upon the eggs, was 41·5° (ib.); so also the heat of the incubating surface of the Bird may rise to 10 degrees (Centigr.) above the ordinary temperature—higher in this passive state than it ever reaches during flight.

The organic condition which determines the hot-blooded or cold-blooded nature of a volant Vertebrate is the separation or the commingling of the arterial and venous bloods in the course of their respective circulations. From the demonstrated absence of any heat-retaining covering of the skin in *Pterosauria*—the kind and amount of negative evidence hereon being decisive—I infer that the black and red sanguineous streams were mixed by intercommunication of the aortic trunks of the right and left ventricles, as in the Crocodile.[2] The plumose integument of *Archæopteryx* bespeaks the separation, not only of the pulmonic and systemic ventricles, but of the arterial trunks thence arising; it was, consequently, hot-blooded, not because it could exert the muscular force required to sustain itself in the air. The all-important condition of the circulating system has wide correlations, not only with the extensive superficies acting upon the surrounding medium, and being reacted upon thereby, but with a rapid and uninterrupted respiration, with an advanced status of the nervous system, especially the brain, involving higher intelligence and more lively and varied instincts, especially the parental. In the organic character determining temperature, breathing, and higher phenomena of life, Birds agree with Mammals and differ from Reptiles.

Birds agree with Implacental Mammals (*Lyencephala*) in the development, by the embryo, of a vascular allantois devoid of villi for placental connection.[3] They agree with the same Mammals and differ from Reptiles in the transversely and deeply folded cerebellum, and in the larger proportion of that and of the cerebrum to the optic lobes. Birds resemble Reptiles in the absence, not only of a corpus callosum, but of a fornix and hippocampal commissure. The *Lyencephala* have the hippocampal commissure, but no

[1] "Faites pendant l'incubation d'une femelle du Python à deux raies (*Python bivittatus*, Kuhl)," &c. 'Comptes rendus de l'Acad. des Sciences,' Paris, 19 Juillet, 1841.

[2] 'Anat. of Vertebrates,' *i*, pp. 510—512, figs. 339, 340.

[3] This character is affirmed to be "of extreme importance, and to define Birds and Reptiles, as a whole, very sharply from Mammals."—Prof. Huxley 'On the Classification of Birds,' loc. cit., p. 416. But, then, the emphatic assertion comes from a writer on Elementary Physiology, who infers the blood of the *Pterosauria* to have been hot because they were able to sustain themselves in air!

corpus callosum; this characterises the Placental Mammalia. Birds differ from other Oviparous Vertebrates in the chalaziferous ovum. The particulars in which Birds differ from all Mammals and agree with Reptiles are comparatively unimportant ones of the skeleton. The occipital condyles (*e.g.*) are more completely blended or unified than in Cetacea. The tympanic is interposed between the mandible and the mastoid, as in Reptiles.[1]

Two genera of Lyencephalous Mammals retain the osteological character common to Birds and Reptiles of the connection of the scapula with the sternum by the intermediation of a fully developed coracoid, and it is one of several and more important characters disproving any sharp definition of the higher warm-blooded Ovipara, at least, from the Ovo-viviparous or Implacental Mammalia.

The scapular arch retains, in *Pterosauria*, its crocodilian simplicity, modified in shape and in the angle at which the scapula meets the coracoid adaptively for the function of flight in the limb suspended thereto. There is, consequently, a close similarity to the same elements in Birds of Flight,[2] but without any trace of the superadded furculum. The articular grooves on the sternum for the coracoids communicate or run into each other at the mid line. The articulation of the corresponding end of the coracoid must be as secure, and yet with as easy a motion, due to a well-turned synovial joint (shown first in *Pterodactylus Woodwardi* and *Pt. simus*),[3] as in any Bird. The confluence of the scapula with the coracoid seems not to be constant in the order *Pterosauria*; and where it has been found, as in *Dimorphodon* and *Pterodactylus Fittoni*, traces of the original suture are present, as represented in the large Neocomian *Pterosauria* in my Monograph of 1859.[4]

In some specimens of *Ramphorhynchus Gemmingi* and in *Ramphorhynchus longicaudus* the scapula and coracoid seemed not to have coalesced.[5] The coalescence is complete and constant (so far as may be inferred from two specimens) in *Dimorphodon*.

For the analysis of the characters of the humerus in *Pterosauria*, I may refer to my Monograph, Suppl. No. III (1861), pp. 13—17, Pl. III. The chief seat of variety is the "radial crest" (Pl. XVIII, 53, *b*, of present Monograph). In the shape and proportions of this extraordinary process *Dimorphodon* resembles *Pterodactylus* more than it does *Ramphorhynchus*. In the proportions of the humerus to the body there is little diversity in the several species.

The antibrachium is commonly two sevenths longer than the humerus. It consists

[1] As a taxonomic character—whatever degree of value may be adjudged to it—this mode of connection of the lower jaw with the skull gains nothing by calling the tympanic 'quadrate bone,' or by affirming it to represent the '*incus*' or the '*malleus*' of Mammalia, whichever may happen to be the favourite fancy of the day.

[2] 'Monograph,' Suppl. No. I (1859), p. 13.

[3] 'Monograph,' Suppl. No. III (1861), p. 12, pl. ii, figs. 7—12.

[4] Suppl. No. I, Pl. III, figs. 1—5.

[5] Von Meyer, op. cit., p. 18.

of two equal-sized, closely and extensively united bones, with one or two slender styliform ossicles attached lengthwise, having the base a little below the distal ends of the radius and ulna. The latter bone shows no pits for the attachment of quill-feathers, as in the hot-blooded volant *Ovipara*. A carpus with one large and one small bone in a proximal row, and with a second large and at least one smaller bone in a distal row, is another character by which the *Pterosauria* manifest their closer affinity to Reptiles than to Birds. The remains of the gigantic species from the Cambridge Greensands have yielded the characters of the two larger carpal ossicles.[1]

Variation, as usual, begins to assert its sway as the segments of the limb recede from the trunk. This is mainly shown in the relative length of the metacarpus. In *Rhamphorhynchus Gemmingi* it is to the antibrachium as 2 to 7, and to the first phalanx of the wing-finger as 1 to 5, or rather less. In *Dimorphodon* the metacarpus is to the antibrachium rather more than 2 to 6, and is little less than one half the length of the first phalanx of the wing-finger. In *Pterodactylus longirostris* the metacarpus is two thirds the length of the first phalanx. In *Pterodactylus longicollum* the metacarpus is almost four fifths the length of the first phalanx of the wing-finger. In *Pt. suevicus* the metacarpus is one eighth longer than the antibrachium.

There are diversities also in the relative length of the phalanges of the wing-finger. In *Dimorphodon* they increase in length from the first to the third. In *Rhamphorynchus Gemmingi* the first and second phalanges are of equal length, and the third is shorter. In *Pterodactylus longirostris*, *Pt. scolopaciceps*, *Pt. Kochii*, they decrease in length from the first to the third, and in a greater degree in *Pt. suevicus*.

The most marked variety, however, if the structure has been rightly determined or be not due to some accidental mutilation of the individual, is that on which Von Meyer[2] has founded his genus *Ornithopterus*, viz. a reduction in the number of phalanges of the wing-finger from four to two, and the articulation of the proximal one to two large metacarpals. The last pointed phalanx of the wing-finger in *Rhamphorhynchus* is rather longer than the penultimate one; in *Ornithopterus Lavateri* it is only one third the length of the penultimate phalanx.

The evidences of pelvic structure in other *Pterosauria*, already referred to, leaves no doubt as to that in *Dimorphodon*, as restored at *s*, 62, 63, 64, in Pl. XX. The expansion of the ischial and pubic elements and the direction of the latter are strong evidences of Reptilian affinity, and decisive differences in the comparison with Birds. Given the greatest number of vertebræ grasped by the ilia, it falls short of the least number presented in the class of Birds, as by certain *Natatores*, which concomitantly manifest a vacillating or waddling gait. Nothing in the structure, proportions, and connections of the pelvic arch squares with the notion of bipedal progression or erect sustentation of the body and wings of the *Pterosaur*. The share taken by the hind limbs

[1] 'Monograph,' Suppl. No. III (1861), p. 17, Pl. II, fig. 6; Pl. IV, figs. 5—9.

[2] Op. cit., p. 25, pl. vi, fig. 5.

in resting or moving on dry ground was that indicated in the restoration of the skeleton in Pl. IV.

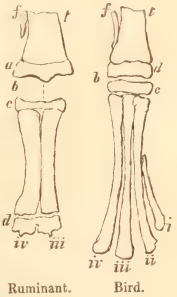
The hind limbs of *Dimorphodon* are, nevertheless, larger and stronger in proportion than in other *Pterosauria*. The femur, in most species, equals the humerus in length, and, in *Dimorphodon*, also in thickness. In *Pterodactylus longirostris* and *Pt. Kochii* the femur is the more slender bone; in *Ramphorhynchus* it is likewise shorter than the humerus.

The tibia, more slender than the antibrachial bones, in *Pterodactylus longirostris* and *Pt. Kochii*, is of equal length therewith. In *Dimorphodon* the tibia is less slender in proportion to the antibrachium, and is longer by one seventh. In *Ramphorhynchus* it is much more slender than the antibrachium, and is nearly one third shorter. The ankle-joint works between the tibia and tarsus, which, as in other Reptiles and Mammals, is distinct from the metatarsus. There is no calcaneal prominence, and the foot admits of easy rotation, as in the 'Restoration,' Pl. XX, fig. 2, where the inner toe is turned outward and the sole presented to view, to show the application of the wing-toe in flight to the interfemoral web.

Whether the trochlear terminal joint of the tibia be ossified from a separate centre in the Pterodactyle as in the Bird requires a specimen of the requisite immaturity for determining. If the hind limbs and pelvis presented the structure for sustaining and moving the animal erect on land, an epiphysial state of the articular ends of the long bones might be physiologically inferred. I conclude, from the absence of the modifications essential to bipedal station and progression in *Pterosauria*, that the articular ends of both femur and tibia, including the distal condyles of the latter bone, were co-ossified with the shaft as in other Saurians.

When in warm-blooded Vertebrates, whether Birds or Mammals, the metapodial elements of different toes coalesce, the epiphyses of such coalesced series, or 'cannon bone,' are usually connate, forming a single bone. As, *e.g.*, at the proximal end of the Cow's and Bird's metatarsus (figs. 3 and 4, *c*),[1] and also even at the distal end of the cannon-bone in Ruminants (fig. 3, *d*). I demonstrated the fact in both the metacarpus and metatarsus of a young Giraffe, in my 'Hunterian Lectures' of 1851. The specimens are Nos. 3631 and 3635 in the Osteological Collection of the Royal College of Surgeons ('Catal.' 4to, 1853, p. 601).

Fig. 3. Fig. 4.



Ruminant. Bird.

The distal trochlear end of the Bird's tibia, in its epiphysial state (fig. 4, *d*), answers to the distal trochlear epiphysis of the Ruminant's tibia (fig. 3, *a*). In its anchylosed state the distal bicondylar trochlear joint or end of the Bird's tibia answers to the distal bicondylar trochlear joint or end of the Pterosaur's tibia. The proximal

[1] "The upper articular surface is formed by a single broad piece. The original separation of the metatarsal bone below into three pieces is plainly indicated."—"On the Anatomy of the Southern Apteryx," 'Trans. Zool. Soc.,' ii (1838), p. 293.

epiphysis of the Bird's metatarsus (fig. 4, *c*) answers to the proximal epiphysis of the Ruminant's metatarsus (fig. 3, *c*).

The interspace between the leg and foot is the seat of variable and inconstant centres of ossification, from zero, as in *Proteus*, *Amphiuma*, *Aves*, to the four ossicles in *Crocodilus*, and the seven ossicles in *Chelone*.

The functions of the hind leg in Birds require peculiarly strong, firm, close-fitting, interlocking joints. Thus, the fibula articulates directly with the femur, and the metatarsus as directly with the tibia. No interposed ossicles are permitted to affect the simple efficiency of this tibio-metatarsal joint in the long-footed feathered bipeds. In quadrupeds and in the short- and broad-footed *Bimana* tarsal ossicles, interposed at the space *b* (fig. 3), have their use. But whether the tarsus exist or not, in the *Hæmatotherma* the articular ends of the long bones begin as 'epiphyses;' and when two or more metacarpals are to become massed into one bone, the epiphysis (*c*) is single—a very significant developmental guide to the homology in question.

The strangest aberrations in homological aims have arisen from a non-recognition of the distinction between teleological and homological centres of ossification.[1] Not only is a tibial epiphysis made into a tarsal bone—and why other epiphyses, such as the proximal one of the tibia, or the distal one of the femur, should be differently treated is not obvious—but new bones by the score are added to the cranial series. 'Basitemporals,' 'prevomers,' 'antorbitals,' 'perpendicular ethmoids,' 'ali-ethmoids,' &c. &c., have been heaped up to obstruct the comprehension of the plain and intelligible nature of the bird's skull.

The four unguiculate digits of the foot are of nearly equal length, but present a slight difference in their proportions[2] in the *Pterosauria*. Cuvier having determined the Lacertian character of the phalangial formula of these digits, viz. 2, 3, 4, 5, adds that, apparently, the fifth digit was reduced to a slight vestige of two pieces in *Pterodactylus longirostris*.[3] Subsequently discovered species have offered a like indication, to which Von Meyer alludes as a rudiment or stump ('stummel') of the fifth toe.[4] No other specimens, to my knowledge, save the third of *Dimorphodon* (Pl. XVIII) and the *Ramphorhynchus* (Pl. XIX, fig. 5) have shown the condition of the fifth digit as of three pieces, viz. a metatarsal (*u*, *v*) and two phalanges (*v*, 1 and 2).

The metatarsal of this toe shows an interesting affinity to that in the *Crocodilia* by its greater breadth and shortness in comparison to the other metatarsals. The two phalanges have proportions and forms which clearly show their adaptive relations as aids in sustaining the interfemoral or caudo-femoral parachute ('Restoration,' fig. 2, Pl. XX).

[1] Owen, "Lectures on the Comp. Anat. of Vertebrate Animals," 8vo, 1846, p. 38.

[2] See Monograph, pl. xi, fig. 3.

[3] "Il paroit qu'ici le cinquième étoit réduit à un leger vestige de deux pièces."—'Oss. Foss.,' vol. cit., p. 374.

[4] "Cuvier, Wagler, und Goldfuss lassen den Fuss aus fünf ausgebilteten Zehen bestehen; in allen Pterodactyln habe ich aber nie mehr als vier solcher Zehen, und höchstens noch einen Stummel vorgefunden."—Op. cit., p. 20.

The crushed condition of most of the long bones in the specimens of *Dimorphodon* show the wall of the shaft to have been compact and thin, the cavity large. Although I have failed to detect such clear evidence of the foramen pneumaticum in these crushed bones as in some of the vertebræ, I cannot resist the inference from the structure of the long bones that they were filled with air in the living animal, as has been demonstrated in remains of the larger *Pterosauria* of the Cretaceous series.[1]

This general osteological character of the *Pterosauria* leads me to offer a few remarks on its relation to their peculiar power of locomotion among *Reptilia*, and to the affinity it may indicate to other groups of volant Vertebrates.

Weight is, of course, indispensable to directed motion through the air; but, given the weight requisite for the action against gravity resulting in flight, whatever structure tends to dispense with additional burthen enables the force to act with more avail—with less unnecessary resistance to overcome.

Where provision is made for unusual flying force, as by the enormous pectoral muscles and concomitant shape of wing in the Swift, the required weight of body called for heavier bones; hence the non-pneumaticity of the skeleton. Diminished flying force, especially with increased bulk of body, is attended with modifications of bony structure obviously adapted, and which have always been recognised in relation, to reduction of weight in the mass to be moved through the air. It is true that the mere quantity of air contained in bones would have an effect inappreciable in aid of the force raising a weight of 5 lb. or 10 lb. from the ground;[2] but the true view of the question is—given a bone of 1 foot in length and 3 inches in circumference, whether the restriction of bony matter to a thinness of $\frac{1}{2}$ a line at the circumference, and a substitution of air for the rest of the diameter throughout the shaft, be not a provision for diminution of weight and conservation of strength which does relate to facilitate locomotion through air?

If the humerus of the Ostrich (No. 1373, Osteological Collection in the Museum of the College of Surgeons, London, 'Catalogue' of do., 4to, 1853, p. 265) be compared, as to weight, with the similarly sized humerus of the Argala Crane (No. 1107, ib., 'Catal.,' p. 214), the difference is striking and suggestive; the latter bone being "remarkable for its lightness, as compared with its bulk and seeming solidity" (ib., 'Catal.' ib.). I demonstrated the cause of the difference by a longitudinal section of

[1] 'Monograph on the Fossil Reptilia of the Cretaceous Formations (Order *Pterosauria*),' ('Pal. Soc. Mon.', vol. v), 4to, 1851, pp. 80, 98, 101.

[2] A writer impugning the physiological inferences of Hunter and Camper, the discoverers of the pneumaticity of the bird's skeleton, remarks:—"A living bird weighing 10 lb. weighs the same when dead, plus a very few grains; and all know what effect a few grains of heated air would have in raising a weight of 10 lbs. from the ground. The quantity of air imprisoned is, to begin with, so infinitesimally small, and the difference in weight which it experiences by increase of temperature so inappreciable, that it ought not to be taken into account by any one endeavouring to solve the difficult and important problem of flight."—Pettigrew, "On the Mechanism of Flight," 'Linnean Transactions,' vol. xxvi, p. 218, 1868.

the two bones. In the Bird incapable of flight the humerus is solid; in the Bird remarkable for the long-continued power of soaring in upper regions of the air the shaft of the bone is a 'thin shell of compact osseous tissue.' The relation of the weight of the volume of air occupying the capacious cavity of the Argala's wing-bone to the total weight of its body need not be taken into account in considering the problem of flight, but the relation of a hollow instead of a solid humerus is a legitimate element in the endeavour to solve that complex kind of animal locomotion. To say that a certain amount of weight in the bird is essential to the momentum of flight is no argument against the reduction to such requisite weight of the body to be upborne. Every structure so tending to lighten the body of a volant animal within the required limit is, and ought to be, recognisable as physiologically related to flight.

By the pneumaticity of the bones of the Pterodactyle, it might be inferred, from a single bone or portion of bone, to have been an animal of flight. For, although certain volant Vertebrates, *e. g.* the Bat and the Swift, may not have air-bones, no Vertebrate save a volant kind has air admitted into the limb-bones. But the effect of such admission, of such substitution of a lighter for a heavier material, is to diminish the weight without impairing the strength of the bone; the legitimate, if not sole, inference, therefore, is that it contributes to perfect the mechanism of flight.

It is a purely adaptive character, and the insignificant, barely appreciable, difference of weight due to difference of temperature in a given bulk of air makes the pneumaticity of the skeleton as available and advantageous to a cold-blooded as to a warm-blooded volant Vertebrate.

In concluding the description of the subjects of the present Monograph I am moved again to express my sense of acknowledgment for the most instructive of the evidences of *Dimorphodon macronyx* due to my friend from the beginning of our palæontological pursuits, the Earl of Enniskillen, F.R.S.; and, whilst fulfilling this pleasurable duty, I would add a testimony to one whose loss Palæontology has much reason to deplore,—to the unwearied and undaunted explorations of the precipitous cliffs of Lyme-Regis by Mary Anning, to which, and to her singular tact of discernment of the feeblest evidence of a fossil in that dark matrix, science is indebted for the discovery of the first evidence of a Pterosaur in 'Lias' of the locality, which has since yielded the grounds for the reconstruction of the strangest representative of the order.

Ramphorhynchus Meyeri, Pl. XIX, fig. 5.—In further illustration of the characters of *Dimorphodon macronyx* I have added to Pl. XIX a figure of a long-tailed Pterosaur from the lithographic slate of Pappenheim, which, in the feebleness of its hind-limbs and the general proportions of the tail, resembles *Ramphorhynchus Gemmingi*, V. M.[1]

[1] See Von Meyer, op. cit., pl. ix, fig. 1.

The present specimen, from Dr. Häberlein's collection, now in the British Museum, shows the fifth or 'wing-toe' of the foot, ib. fig. 5, *v*, which had not been preserved in previously described specimens of the genus.[1] At least thirty-four vertebræ extend beyond the sacrum; thirty-eight caudals are the reckoned by Von Meyer in the specimen of his *R. Gemmingi* with the best preserved tail;[2] but this difference would not have yielded sufficient ground for specific distinction. There are, however, differences in the length of the parts of the hind limb which indicate this to have been longer in proportion to the tail and the 'symphysis mandibulæ' than in *R. Gemmingi*.

	R. Meyeri.		*R. Gemmingi* (pl. ix, V. M., op cit.).	
	in.	l.	in.	l.
Length of femur	1	2½	1	0
,, tibia	2	0	1	8
,, 1st toe	1	6	1	2½
,, 2nd toe	1	9	1	4
,, 3rd toe	1	11½	1	6
,, 4th toe	1	10½	1	3
,, 5th toe	0	9		

In both specimens the number of phalanges of the toes increases from the first or innermost to the fourth, in the usual saurian ratio, 2, 3, 4, 5. In *Ramphorhynchus Meyeri* the fifth toe consists, as in *Dimorphodon*, of two phalanges, the first being six lines in length, the second three lines, and ending in a point. The metatarsal of this 'wing-toe' is short, broad, and flattened, with a convex outer border at its basal half.

The bones of the left hind limb are well preserved in the specimen figured.

The caudal vertebræ are surrounded by the bone-tendons. Their proportions, as shown in the figure, accord with those in *Dimorphodon*, Pl. XIX, fig. 4.[3] The posterior dorsal vertebræ of *Ramphorhynchus Meyeri* show the broad diapophyses supporting the ribs, which are more slender than those at the fore part of the chest. The symphysis mandibulæ is one inch six lines in length, including the edentulous pointed end. Four pairs of long slender laniary teeth are preserved at the fore half of the symphysis. The teeth at that part of the lower jaw in *Ramphorhynchus Gemmingi* are fewer in number and less closely arranged.[4]

[1] "Ein Stummel wur nicht mit Sicherheit zu ermitteln."—Von Meyer, op. cit., p. 72.

[2] Op. cit., p. 69.

[3] This figure has the neural surface downward in the Plate.

[4] Compare with Von Meyer, op. cit., pl. ix, fig. 1, and pl. x, fig. 1.

PLATE XVII.

Dimorphodon macronyx.

Skull and parts of the skeleton : nat. size.

From the Lower Lias of Lyme Regis. In the British Museum.

DIMORPHODON MACRONYX

om nat on Stone by J Erxleben

PLATE XVIII.

Dimorphodon macronyx.

Skull and parts of the skeleton: nat. size.

From the Lower Lias of Lyme Regis. In the British Museum.

PLATE XIX.

Dimorphodon macronyx.

Fig.

1. Bones of fore foot and part of wing-finger.
2. Pelvis.
3. Anterior caudal vertebræ.
4. Vertebræ of entire tail, with surrounding bone-tendons.

From the Lower Lias of Lyme Regis, Dorsetshire.

Rhamphorhynchus Meyeri.

5. Dorso-lumbar, sacral, and caudal vertebræ, part of pelvis, with bones of the pelvic limbs.
6. Fore part of mandible and teeth.

From the Lithographic Slate, Pappenheim, Bavaria.

7. Second phalanx of wing-finger of *Pterodactylus validus.*
8. Distal end, and section of shaft, of tibia of *Pterodactylus curtus.*
9. Ib. ib., side view, of do. do.
10. Section of second phalanx of wing-finger of *Pterodactylus nobilis.*

From the Wealden of Sussex.

All the specimens of the natural size. In the British Museum.

PLATE XX.

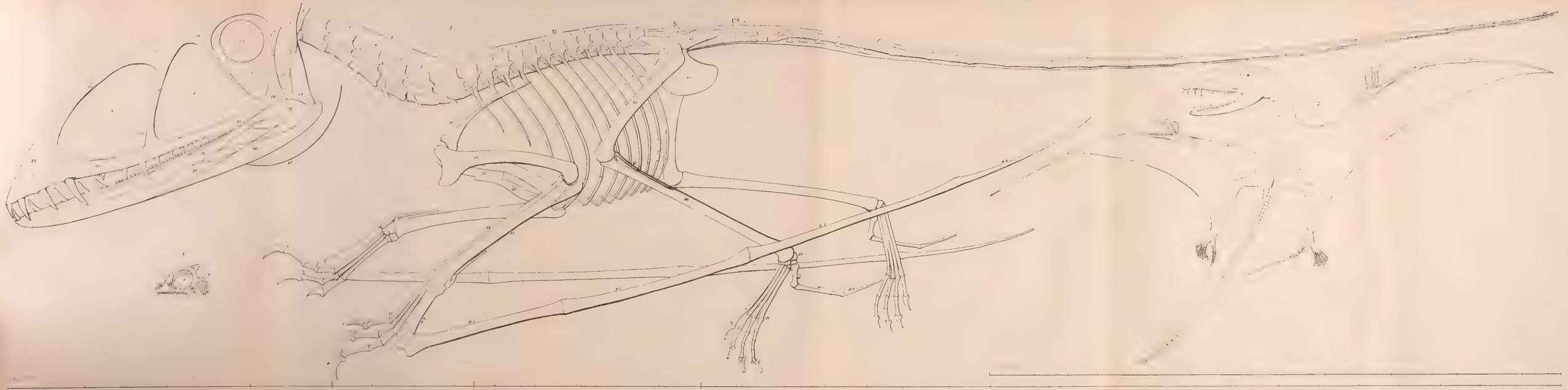
Dimorphodon macronyx.

Fig.

1. Restoration of the skeleton : nat. size.

2. Restoration of entire animal : reduced (see 'Scales' at foot of plate).

3. Side view of the skull of a recent Saurian (*Lyriocephalus*).



THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1869.

LONDON:
MDCCCLXX.

MONOGRAPH

ON THE

BRITISH FOSSIL

CETACEA

FROM THE

RED CRAG.

BY

PROFESSOR OWEN, F.R.S., D.C.L.,

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE, ETC. ETC.

No. I,

CONTAINING

GENUS ZIPHIUS.

Pages 1—40; Plates I—V.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1870.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

MONOGRAPH

OF

BRITISH FOSSIL CETACEA

OF THE

'RED CRAG.'

Genus—ZIPHIUS, *Cuvier*.[1]

THE more abundant evidences of *Cetacea* from the 'Red Crag' of Suffolk are teeth and ear-bones, by which, in 1842 and 1843, remains of the order were determined in that formation and locality.[2] Portions of cranium, chiefly rostral, referable to the Ziphioid family, are rare; and these are always more or less rolled and worn,[3] a condition which, with the break-up of the cranial parts of the skull, and the scattering of its densest bony parts, with detached teeth, indicates the long-continued operation of sea-waves, breakers, and currents, on the deposits of a Tertiary period, which, in England, occupies a very limited area. Nevertheless, there are grounds for estimating the amount of these deposits, which must have been broken up and transported in order to furnish the Cetacean nodules of the 'Red Crag,' at thousands of cubic acres. The remaining débris of older Pliocene with probably Upper Miocene beds, known as 'Red Crag,' occur in patches from Walton-on-Naze, Essex, to Aldborough, Suffolk, extending from five to fifteen miles inland. The thickness of the Red Crag is variable, but does not now average more than 10 feet; its greatest observed thickness is 40 feet, including some sand-beds at the top, which have no shells. Broken-up septarian nodules, and other so-called 'rough stones,' the débris of washed-off 'London Clay,' form in some places a rude flooring to the Red Crag, and the Cetacean with other phosphatic

[1] 'Recherches sur les Ossemens fossiles,' 4to, 1823, tom. v, pt. 1, p. 352.

[2] "Reports on British Fossil Mammalia," 'Trans. Brit. Assoc.,' 1842. At this date I was misinformed as to the formation in which the 'physeteroid tooth' described in that 'Report' had been discovered. Mr. Charlesworth traced the origin of the then unique fossil to the Red Crag at Felixstow. In the following year (1843) Prof. Henslow submitted for my determination and description a number of 'concretions' from the same formation and locality, which are described in the 'Appendix' to Prof. Henslow's papers "On Concretions in the Red Crag," &c., 'Proceed. Geol. Soc. London,' vol. iv (Dec., 1843), p. 283.

[3] As in the specimen, closely resembling *Ziphius longirostris*, Cuv., described and figured in my "Description of Mammalian Fossils of the Red Crag," 'Quart. Journ. Geol. Soc.,' vol. xii, 1856, p. 228, fig. 24.

'nodules,' 'concretions,' or 'cops' of the diggers[1] are most abundant immediately over the 'rough stones.'

It will be understood that I use here, as in my 'Memoir' of 1856, the term 'Red Crag' in the sense in which it was first applied by Edward Charlesworth, Esq., F.G.S., as "characterised by its ferruginous colour;"[2] fully recognising, with the same persevering and accurate explorer of the Eastern Counties' Crag-beds, that the rolled and fragmentary Cetacean remains belong to a deposit older than those which, by their testaceous fossils, may be truly or strictly defined as 'Red Crag:' that the older deposit in question—more or less destroyed and broken up in Suffolk—answers, in time, to the better preserved Belgian 'Sable noir' of the 'Système Diestien' of Nyst and von Koenen;[3] and also that, though I have received Cetotolites from the London Clay of Essex, I hold the same opinion, as does Prof. Van Beneden in regard to his '*Placoziphius*,' from the 'Rupelian Clay' of Edeghem,[4] that they have gravitated into such older deposits in the course of their agitation and rolling by the surf-waves.

By the term *Ziphius* I understand, with Cuvier, a genus having close relations with *Physeter*, Linn., and still closer with *Hyperoodon*, Lacép.[5] (if it really merit generic distinction therefrom), characterised by a more or less elongate, slender, edentulous, beak-shaped upper jaw, or 'rostrum,'[6] varying in form, abruptly and considerably expanding between the orbits, behind which both maxillaries and premaxillaries rise to build, with the frontals, a boundary wall concave upward and forward, the middle part of which, formed by the premaxillaries and nasals, arches forward, so as more or less to overhang the nostrils.[7] In the mandible or lower jaw the teeth are reduced usually to a pair, which are subterminal or terminal in position, and are most conspicuous, or may only be visible, in the male sex.[8]

In the existing species of this genus, discovered since the date of the classical

[1] An abbreviation, according to our Saxon proclivity, of 'coprolites,' which these nodules were generally supposed to be prior to my discovery, in 1840, of the nature of the coprolitoid fossil in Mr. John Brown's collection, afterwards figured in 'British Fossil Mammalia,' p. 536, figs. 219, 226, and 227.

[2] 'Proceedings of the Geological Society of London,' vol. ii (May, 1835), p. 196.

[3] 'Geological Magazine,' 1867, vol. iv, p. 501.

[4] See the excellent Memoir by Mr. Godwin-Austen, 'Quart. Journ. Geol. Soc.,' vol. xxii, 1866, p. 228.

[5] *Ziphius*—"a de grands rapports avec le cachalot et encore de plus grands avec l'hyperoodon."—'Ossem. Foss.,' tom. cit., p. 351.

[6] "La partie du museau formée comme à l'ordinaire par les maxillaires et les intermaxillaires, est une espèce de cylindre ou de prisme quadrangulaire dont les angles sont arrondies."—Ibid., tom. cit., p. 354.

[7] "Ces intermaxillaires—remontent le long des côtés des narines, et se recourbent en avant pour former avec les deux os du nez, *n*, *n*, qui sont encastrés entre eux, une espèce d'auvent sur le dessus des narines."—Ib., p. 351.

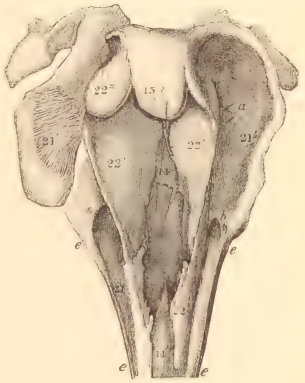
[8] The taxonomic applications of the teeth in the species of *Ziphius* is affected by the singular arrest of development of the dental system. Rudiments of teeth may be found hidden in the gum, filling the alveolar groove of the premaxillaries, from which one small pair may slightly project, according to the age of the individual. Small teeth, or concealed rudiments, may precede or follow the pair, or two pairs, which are better developed in the lower jaw. As generic characters, I deem these dental conditions to be valueless.

work cited, the blow-hole is single, transversely crescentic, with the horns forward; there is a small but rather high falcate dorsal fin, the pectorals are small and placed low, the caudal broadly and terminally emarginate.[1]

The rostrum in *Ziphius*, as demonstrated in the skulls of the existing species above described, is mainly composed of the maxillaries and premaxillaries; but it likewise includes at the medial line, along a greater or less extent from the base, the prefrontal and the vomer, while at its base are parts of the palatines and pterygoids.

For a right use of a generic name it is requisite, in case of doubt, to refer to the specimen or specimens of species on which the genus has been founded, called 'type-specimens' by those naturalists who use the word 'type' in that sense. The genus *Ziphius* was defined by Cuvier from characters afforded by more or less mutilated skulls of three or more species. They were mainly derived from the least mutilated specimen, which had been found by a peasant on the sea-shore ("sur le bord de la plage") between the village of *Fos* and the embouchure of *Galégeon*, in the Department of the "Bouches-du-Rhône," near the canal leading from the marsh of 'l'Estomac' to the sea.[2] The occiput and most of the cranial cavity were wanting; but the specimen showed the temporal fossæ with the orbits and interorbital expanse of bone, including the nostrils and the whole of the rostrum, which was edentulous. It is figured in the 'Ossemens Fossiles,' tom. v, pt. 1, pl. xxvii, fig. 3 ($\frac{1}{4}$ the nat. size). I reproduce in the cut, fig. 1, the original figure of part of this specimen on a larger scale, given by Prof. Gervais, in his 'Zoologie et Paléontologie françaises,' 4to, pl. xxxviii, fig. 2. These figures show that the premaxillaries (22) forming the end and upper part of the sides of the rostrum expand as they rise (22), curving outward and upward, and inclining forward at their summits (22^x) to support a pair of small massive nasals (15) wedged in grooves between them: the expanding nasal plates of the premaxillaries bound or form the lateral walls of the cavity (prenasal fossa), into which opens posteriorly the upper outlet of the nostrils, the septum of which (14) extends forward, bisecting in part the prenasal fossa. The premaxillary wall or ridge dividing this fossa (22′) from the maxillary (21′) is represented on the left side of Cuvier's fig. at *o*, *o*; the rostral part of the premaxillary (22, fig. 1) is marked *g′* in the same figure. The maxillaries (21, fig. 1, pl. xxvii, fig. 3, *e*, *e*, *f*, in the 'Ossem. Foss.')

Fig. 1.



Ziphius cavirostris, Cuv.

[1] As in *Ziphius micropterus*, 'Mémoires de l'Académie Royale de Bruxelles,' tome xii, pl. i; and in *Ziphius patachonichus*, 'Anales del Museo Publico de Buenos Ayres,' tom. i, pl. xv.

[2] 'Ossem. Foss.,' tom. cit., p. 150.

greatly extend transversely the interorbital platform, of which they constitute the two large lateral wings or concavities; they are continued forward along the under part of the sides of the rostrum, and for some distance in the form of an outstanding ridge (fig. 1, *e*, *e*). The upper mid-tract of the rostrum ('vomer,' *h*, of Cuvier) is formed by a production of the 'lamina perpendicularis æthmoidei,' answering to my prefrontal,[1] of singular thickness (fig. 1, 14). The lower mid-tract of the rostrum is, in part, formed by the veritable vomer. This rostrum was edentulous.

From the longitudinal extent of the prenasal fossa, through interruption of ossification of the prefrontal, between 14 and 14′, in fig. 1 (*k* and *h* of fig. 3, pl. xxvii, 'Oss. Foss.'), Cuvier gave to this original type of his new genus the specific name *Ziphius cavirostris*. He notes the cetacean character of want of symmetry in the twist of the nasal bones to the left; and that the contiguous plate of the right premaxillary is the largest, while, in the fossa (ib., *o*), the left premaxillary is the largest ("dans la grande fosse c'est le gauche qui reprend de la largeur et qui rejette vers la droite la suture qui la sépare de l'autre" (tom. cit., p. 351). The posterior wall of the nasal chamber is perforated on each side the septum by a single orifice; Cuvier writes—"pour la communication du nerf olfactif avec les cavités nasals:" it more probably transmitted, as in *Delphinidæ* and *Hyperoodon*, the nasal branch of the first division of the trigeminal nerve, with accompanying branches from the anterior meningeal artery.

Cuvier adds that this skull was very heavy and very dense ("cette tête est très pesante, très dure," ib., p. 352), by which he may be recording another character of his genus, viz. the singular petrosal density of much of the osseous texture; this character, however, he believed to be due to posthumous petrifaction of the specimen, and so deemed it to belong to a fossil Cetacean. The specimen, now in the Museum of Comparative Anatomy at the Jardin des Plantes, though not "complétement pétrifiée en calcaire," ib., does appear to have imbibed calcareous matter, probably by long imbedding in the superficial deposit from which it had been dislodged.

The new and more enlarged view of the expanded interorbital part of Cuvier's original or type-specimen of *Ziphius cavirostris*, which Prof. Gervais has given,[2] is chiefly for the purpose of comparing it with a similar view of the skull of a *Ziphius* found in 1850, on the beach of Aresquiers, Department of Hérault, which *Ziphius*, still existing in the adjoining seas, he refers to the same species—*Z. cavirostris*.[3] In this instance the mandible was obtained, showing one of the series of germs of teeth in the alveolar groove of each ramus to have been developed at the end of the symphysis.[4] The small size of this protruding tooth may relate to sex, and indicate the stranded *Ziphius* to have been a female. M. Gervais notes that the prenasal fossa (his 'excavation conchoïde') is deeper and less expanded ("moins évasée et plus considerable," op. cit., p. 8) than in Cuvier's specimen, owing to differences in the direction and development of the premaxillary walls of the fossa. But M. Gervais is inclined to include these differences within the range of sexual or individual varieties of

[1] 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, p. 58.

[2] 'Zoologie et Paléontologie françaises,' 4to, pl. xxxviii, fig. 2; woodcut fig. 1 of present Monograph.

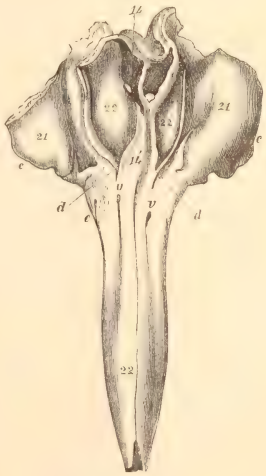
[3] Op. cit., p. 154, pl. xxxviii, fig. 8, and pl. xxxix, figs. 2—7.

[4] Op. cit., pl. xxxix, figs. 4, 4*a*.

the same species of *Ziphius*. There seems, however, to be another difference, if we may judge from the figure of the upper surface of the cranium from Aresquiers, viz. the continuation of a canal more or less unoccupied by the prefrontal (or so-called 'vomer') along the upper part of the rostrum to its termination. The text of M. Gervais supplies nothing to correct the plain inference from his figure. Moreover, the new and valuable figures from the original type-skull of *Ziphius cavirostris*, in the Museum at the Jardin des Plantes (pls. xxxviii, fig. 2, and pl. xxxix, fig. 1, Gervais, op. cit.), confirm the accuracy of Cuvier's account of the proportion contributed to the rostrum by the prefrontal (fig. 1, 14′: 'vomer, *h*, " d'une singulière épaisseur," Cuv., tom. cit., p. 351); whereas the appearance of the homologous tract in the *Ziphius* from Aresquiers (Gervais, pl. xxxviii, fig. 1) plainly shows it to form a narrower and less elevated tract at the upper part of the rostrum. If this should signify something more than sexual or individual difference, I nevertheless concur with Prof. Gervais in rejecting its interpretation as a generic distinction.

Returning to Cuvier's illustrations of his (supposed extinct) genus *Ziphius*, we find it, next, illustrated by veritable fossils, from what is now known as the 'Middle Crag' at Antwerp. *Ziphius planirostris*, Cuvier, is founded on specimens (figs. 2 and 3) which include the rostrum, and so much of the expanded bases of the maxillaries and premaxillaries, with the palatines and pterygoids, as give the characters of the nasal passages and base of the rostrum. The posterior part of the basal or interorbital expansions of the maxillaries and premaxillaries are, with the overarching nasals, broken away. In the second of the two fossils in the above general condition, to which Cuvier applied the names *Ziphius planirostris*, he recognised and points out differences which might be of specific value.[1]

Fig. 2.



Ziphius planirostris, Cuv.

Regarding the first as the type of Cuvier's *Ziphius planirostris*, its more perfect condition permits both upper and lower apertures of the nasal passages to be seen—a condition of value in appreciating the generic osteological characters of *Ziphius*. In the upper view (fig. 2) the prefrontal (14) forms the posterior wall and septum of the vertical respiratory canals, the septum being continued into a suddenly expanded tract (14′), which advances with an unsymmetrical bend to the right, as in *Ziphius Layardi*, Plate I of this Monograph. Any further definite tracing of this mid-tract is not afforded by Cuvier's reduced figure, beyond the canals (*d*, *d*) which terminate the pre-

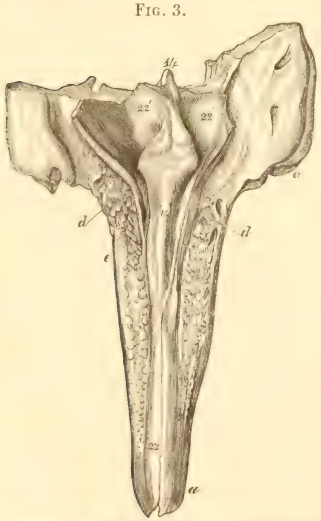
[1] "L'autre morceau—plus mutilé que le premier, offre des différences, qui pourroient passer pour spécifiques."—Op. cit., p. 355.

nasal fossæ (22, 22′) anteriorly, and partially reappear at *v*, *v*, fig. 2. The premaxillaries expanding at the sides of the nostrils develope each a ridge, extending toward the nasals and dividing the prenasal fossæ from the maxillary ones (21′, 21′).

The specimen figured ('Oss. Foss.,' loc. cit., pl. xxvii, figs. 4, 5, 6; fig. 5 being copied in my figure 2) shows a rostrum of similar proportions to that in the type-species (fig. 1, and 'Oss. Foss.,' loc. cit., fig. 3); but the prenasal fossæ are more shallow, the premaxillary walls being less elevated; and a more marked difference is seen in the continued ossification from the 'septum narium' or 'lamina perpendicularis' forward (fig. 2, 14′), expanding to form a broad and dense mid-tract along the upper surface of the rostrum (as at *f* in Cuvier's figures 4 and 5, "crête plate, qui me paroît appartenir au vomer par sa partié inférieure et élargie," ib., p. 354). I shall subsequently show that this mid-tract does in the present and some other species of *Ziphius* coalesce by its lower expanding surface with the canaliculate vomer, and in that respect, but in that only, may be said to belong thereto.

The third specimen, also fossil (fig. 3), and from the same Mid-tertiary formation and locality, resembles the second in the proportions of the rostrum, and in the continuous ossification (14′) of the cartilage extending forward from the 'septum narium' (14), and expanding as shown at *f* in Cuvier's pl. xxvii, fig. 7. Only, whereas in fig. 2 ('Oss. Foss.,' ib., fig. 5) the prenasal fossæ terminate anteriorly, each in a foramen leading to a canal which reappears further forward on the surface of the snout; in fig. 3 ('Oss. Foss.,' ib., fig. 7) the fossæ are continued by open canals (*d*, *d*) to the same part of the snout, gradually contracting forward to such canals. Moreover, in the present species, which may be noted as *Ziphius Cuvieri*, the upper surface of the maxillaries, from the anterior third of the rostrum to the sides of the prenasal fossæ (*d*, *d*), is roughened by irregular tubercles and ridges. This character appears in different degrees in other fossil *Ziphii*, e. g. *Z. gibbus*, t. ii, fig. 2, *e*; *Z.* (*Ziphiopsis*, Du Bus.) *phymatodes*, &c.

Fig. 3.



Ziphius Cuvieri, Ow.; *Z. planirostris*, No. 2, Cuv.

From the expanded superorbital platform of the maxillaries (*c*, *c*, figs. 2 and 3), these bones rapidly contract, with a concave outline to the base of the rostrum, along the sides of which a ridge (*e*) is continued for some way, gradually subsiding.

The third species of *Ziphius*, Cuv., is represented by a petrified edentulous rostrum ('Oss. Foss.,' loc. cit., pl. xxvii, figs. 9, 10), with so much of the base as shows it to be of similar composition with that in the preceding *Ziphii*, but in shape longer and more slender. As

the upper mid-tract of the rostrum shows a mesial linear groove, Cuvier attributes its formation to the premaxillaries; but in the previous species the anterior continuation of the so-called 'vomer' is similarly grooved. The veritable premaxillaries are perforated at their basal expansion, as in *Ziphius planirostris*, by the incisive foramina (marked *d*, *d* in the illustrations of the present Monograph). The maxillaries, where, tracing them backwards, they begin to expand, show the lateral ridge marked *e*, and the outlets of the suborbital canal. On this fossil rostrum Cuvier founds his species *Ziphius longirostris*.

I now proceed to the inquiry, whether any existing species of Cetacea manifest characters which can legitimately be interpreted as generically those of the *Ziphius* of Cuvier, and whether they manifest corresponding modifications in the construction of the rostrum with those interpreted by Cuvier as of specific value.

I shall commence with the description of one of the series of Cetacean skulls transmitted from the Cape of Good Hope, for description and comparison, to the British Museum. Two figures of the instructive specimen in question have been published by my colleague Dr. Gray, F.R.S.; one is a copy of a drawing by Mr. Trimen, of Cape Town, under the name *Hyperoodon capensis*;[1] the other is an original woodcut from the specimen itself, as exemplifying the genus *Petrorhynchus*, Gray.[2] It would be an ill return for Mr. Layard's liberal labour of transmission if the British Museum did not furnish him with such anatomical accounts of his rarities as might serve or help to determine their genus and its true affinities.

ZIPHIUS INDICUS, *Van Beneden*;[3] PETRORHYNCHUS CAPENSIS, *Gray*; (figs. 4, 5, 6, and 7).

This species exhibits the interesting and instructive condition of a partial ossification of the prefrontal or cranio-facial cartilage—so-called 'vomer' (fig. 4, 14, 14′). In this skull the cranio-vertebral elements continued by or into that cartilage can be completely traced. The prefrontals form, as usual, the posterior concave wall of the nasal passages, where each is perforated by one larger foramen, for the trigeminal olfactory (?), and a few smaller vascular foramina; they coalesce at the mesial line, and rise as a low buttress-like ridge abutting obliquely and unsymmetrically against the nasal bones; the coalesced parts then extend forward, as the thin 'septum narium,' with a sharp, free, superior concave border; the plate slightly thickens as it descends to be wedged into the vomer, expands more as it advances in front of the nasal apertures, but subsides to the bottom of the prenasal fossa, sinking almost to the level of the vomer, with which it has coalesced, and there, at 14, shows a surface from 2 to 3 inches across and 9 inches in length, concave both lengthwise and transversely, in which concavity was lodged the

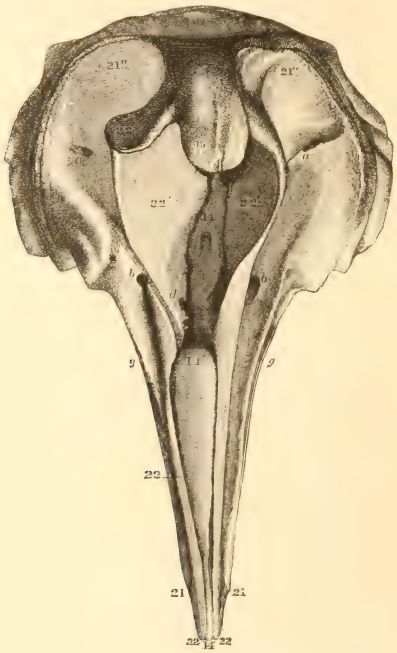
[1] 'Proc. Zool. Soc.,' April 11, 1865, p. 359.

[2] Ib., June 27, 1865, p. 527.

[3] 'Mémoires couronnés et autres Mémoires de l'Académie Royale de Belgique,' t. xvi, 1863.

remaining prefrontal cartilage, into which had extended a few spiculæ of bone from the lateral premaxillary walls (22′, 22′) of the deep cavity left between them by reason of the defect or arrest of ossification of this part, as in *Ziphius cavirostris* (fig. 1). It is most interesting to find indications of a similar structure in the original figure taken from Cuvier's type-specimen of *Ziphius cavirostris,* in pl. xxxviii, fig. 2, of Prof. Gervais' excellent work above cited.[1]

Fig. 4.



Ziphius indicus, V. B.; 1-8th nat. size.

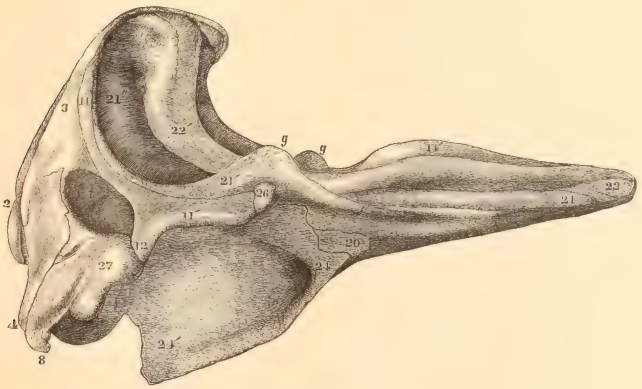
In *Ziphius indicus*, at the distance of 9 inches from the upper nostrils, ossifica-

[1] Dr. Gray supposes this figure to be from a specimen distinct from that figured by Gervais, in his plate xxxix; he observes, "The skull of this genus (viz. *Petrorhynchus*) resembles in several particulars the skull of *Ziphius cavirostris* figured by Gervais ('Zool. et Paléont. franç.,' t. 39); but the cavity on the crown of that species is only slightly developed, though it is apparently rather more developed in the other specimens figured on the plate, t. 38 (figs. 1, 2) of that work, and the vomer is sunk in a groove, as in the other Ziphioid genera" ('Catal. of Whales, &c.,' p. 346). But the figure 1 of pl. xxxviii, Gervais,

tion has abruptly proceeded to convert the prefrontal cartilage into a dense mid-tract of bone (fig. 4, 14′) of a petrosal texture, and of unusual breadth, viz. 2 inches 9 lines, at about three inches in advance of the part where this ossification gains the level of the premaxillaries. Prof. Gervais's figure shows the ossified prefrontal (his 'vomerine') tract to rise and expand with similar abruptness in the type *Ziphius cavirostris* (cut, fig. 1, 14′). From its broadest part, in *Ziphius indicus*, the mid-tract contracts, at first gradually, then more suddenly and unsymmetrically; the sutural fissures between it and the premaxillaries (22) becoming shallower and widening into grooves, which demonstrate at their bottom the complete coalescence of the prefrontal and premaxillary elements of the rostrum. The grooves are continued to the end of the rostrum, and indicate the share contributed there by those bones respectively.

The side walls of the rostrum, formed by the premaxillaries (22), rise almost vertically from the sutures with the maxillaries (21), and terminate above in a border, which is obtuse for the first six inches, from the end of the snout backward; it then becomes a sharp margin bent inward, so as partly to overlap the mid-tract (14′). The inward inflection becomes greater, and the border is again thickened and also roughened where

Fig. 5.



Ziphius indicus, V. B. 1-8th nat. size.

it arches over the part of the cavity left by the unossified part of the prefrontal (14). The same modification characterises the type-specimen of *Ziphius cavirostris* (fig. 1, 22^{s}).

is an enlarged upper view of part of the same skull ('de la plage des Aresquiers'), as the upper view of the entire skull given in figure 2 of pl. xxxix; while figure 2 of plate xxxviii is a view of the upper surface of part of Cuvier's specimen ('de la plage de Fos.'), of which a side view of the whole specimen is given in fig. 3, pl. xxxix, of the 'Zool. et Paléont. françaises.'

The premaxillaries then expand and diverge (22′), curving outward and upward to articulate with the sides of the basal half of the short and massive nasals (15). These are rather turned to the left. The nasal plate of the right premaxillary (22′) is broader and less vertical than that of the left; it is, as it were, pushed somewhat outward and downward. The kind and degree of this symmetry closely resemble those described and figured by Cuvier in his type-specimen of *Ziphius cavirostris*.[1]

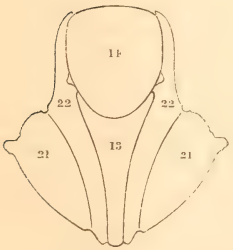
The cavity, so circumscribed or bounded externally by the premaxillary plates, answers to that marked *d* in figs. 4, 5 and 6, of pl. xxvii, op. cit., of Cuvier's *Ziphius planirostris*; we shall find it common to all the *Ziphii*, with varying proportions [such as are exhibited by the recent *Ziphius Layardi*, Pl. I, fig. 2, of the present Monograph]. The maxillaries, forming, in *Ziphius indicus*, the lower and lateral parts of the rostrum to within about three inches of its free end (fig. 5, 21), gradually expand vertically and transversely as they pass backward, bending inward below, along the palato-premaxillary and palato-vomerine sutures, until the right meets the left maxillary at the mid-line (fig. 7, 21), in advance of the palatine bones (ib., 20). The suture between the maxillaries is about 5 inches long. This palatine part of the maxillary is convex transversely and smooth. It is bounded above for the first five inches by a narrow (ecto-maxillary) groove, the upper border of which projects, at first slightly, and then extends outward, forming behind the groove a rough (ecto-maxillary) ridge (fig. 5, *e*), gaining both in transverse and vertical extent or thickness until it reaches the middle of the naso-premaxillary plate, where it swells into a convex tuberosity (fig. 5, *g*), at the part answering to that in which the vertical walls rise in *Hyperoodon*. Beyond the tuberosity the maxillary extends outward, articulating first with the malar (26), then with the superorbital tract (11) of the frontal, sweeping upward, in a graceful curve, with that bone to join the base of the nasals. This broad interorbital plate of the maxillary forms, with the similarly expanded nasal plate of the premaxillary, a large and moderately deep semilunar cavity, perforated by the (antorbital) canal and foramen, transmitting a branch of the second division of the trigeminal (*a*). The cavity contracts and deepens forward, answering to that so marked in the canal between the tuberosity (*g*) and the beginning of the premaxillary expanse, and there opens the second canal (fig. 4, *b*), continued from the antorbital one, for the chief branch of the second division of the trigeminal, mainly answering to the suborbital or antorbital nerve in land mammals, as in *Physeter* (*Euphysetes*) *simus* ("Indian Cetacea," 'Trans. Zool. Soc.,' vol. vi, pl. xiii; *Phocæna brevirostris* (ib., pl. ix). The ectomaxillary ridge (fig 5, *e*) is grooved along the thick margin of its basal or hinder half. A narrower groove, commencing three inches in advance of the foramen (*b*, fig. 4), extends forward along the line of the maxillo-premaxillary suture to the anterior termination of the maxillary. The whole of the rostral part of the maxillary extends outward, beyond the subvertical plane of the side-wall formed by the premaxillary, and in a degree augmenting

[1] 'Oss. Foss.,' tom. cit., pl. xxvii, fig. 3.

as it approaches the base of the rostrum. The transverse section of the middle of the rostrum (at the part marked 13 in fig. 7) thus gives the figure shown in outline, by woodcut, fig. 6, in which 14 marks the petrosal production of the 'prefrontals,' 22 the premaxillaries, 21 the maxillaries, and 13 the vomer. As far as can be judged from the figure of the rostrum in Cuvier's type-specimen of *Ziphius cavirostris*, it would yield a very similar form of transverse section.

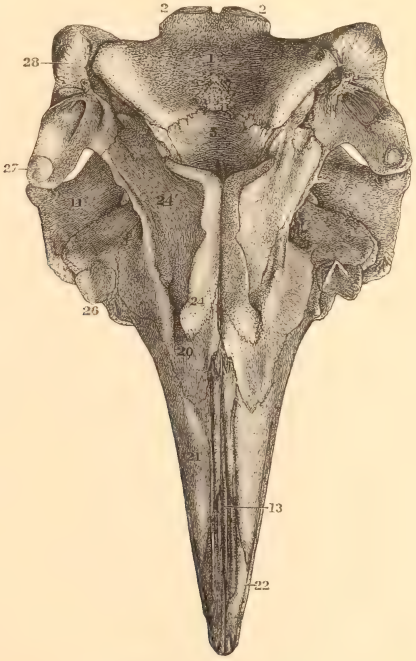
On the palatal surface of the rostrum of *Ziphius indicus* (fig. 7) the premaxillaries (22) alone form the anterior $4\frac{1}{2}$ inches; the vomer (13) then appears at the mid-line for an

Fig. 6.



Section of rostrum, *Ziphius indicus*.
1-4th nat. size.

Fig. 7.

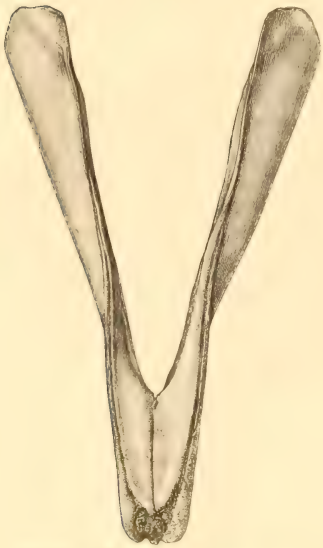


Ziphius indicus. 1-8th nat. size.

extent of 11 inches as a convex ridge, not exceeding 5 lines across at its broadest part. The premaxillaries unite with the first six inches of the exposed tract of the vomer, the maxillaries (21) with the succeeding five inches. About three inches behind the vomerine tract the palatines (20) meet at the mid-line along a suture $2\frac{1}{2}$ inches in extent; then follow the broad and deep pterygoids (24), extending downward with their lower margins

bending outward from the line of their mid-palatal suture, which is 6 inches in longitudinal extent. The free lower borders of the pterygoids approximate and thicken as they pass backward, diminishing but not obliterating their interval, at the hind end of which the thick border of the pterygoid bends abruptly outward for about three inches, terminating in a sharp angle answering to a hamular process. The expanded fore part of the malar (figs. 5 and 7, 26) shows the beginning of the styliform backward continuation. The squamosal (ib., 27) has a prominent, flat, oval facet at the fore part of the 'glenoid cavity,' the concave articular surface of which is defined at the back part. Other anatomical particulars not specially concerning the subject of the present Monograph I here omit.

Fig. 8.



Mandible of *Ziphius indicus*. 1-8th nat. size.

An upper view of the mandible is given in cut, fig. 8. The sex of the individual affording the above-described skull is not known. From the size of the alveoli indicating that the terminal pair of mandibular tooth-germs were developed, it was probably a female. In Prof. Van Beneden's specimen the developed teeth were but $2\frac{1}{2}$ inches (0·065 mm.) in length, and consisted chiefly of root, thickly coated with cement.

From the correspondence of structure of the upper jaw of the present Cetacean with that in the specimens affording to Cuvier the characters of his genus *Ziphius*, I refer it thereto; the degree of ossification of the prefrontal or craniofacial cartilaginous constituent of the rostrum, with the proportions of the rostrum, I interpret as specific, and adopt the *nomen triviale* by which this existing species of *Ziphius* has been designated by Prof. Van Beneden (loc. cit.).

Ziphius Layardi (Dolichodon, *Gray*). Plate I.

Having shown, in *Ziphius indicus*, a partial ossification of the cartilage continued along the groove of the vomer from the septum narium, or coalesced prefrontals, as in *Z. cavirostris*, Cuvier, I now proceed to demonstrate, in another existing species, the

condition of that upper mid-tract of the rostrum which Cuvier made distinctive, with other specific characters, of his *Ziphius planirostris* and *Ziphius longirostris*.

I find this character in the composition of the rostrum of the skull of an adult male of *Ziphius Layardi* (*Dolichodon*, Gray) liberally transmitted, like that of *Z. indicus*, for description, to the British Museum, by the excellent naturalist, Mr. Edgar L. Layard, F.L.S., &c., now at the Cape of Good Hope, after whom the species is named.[1]

In this skull (Pl. I) the premaxillaries (fig. 1, 22') retain, at their hind part, the sutures connecting them with the nasals (15) and maxillaries (21'), where they bound the upper apertures of the nostrils; the sutures connecting them with the prefrontal (figs. 1 and 2, 14) and maxillaries are traceable a short way along the base of the rostrum, and then become obliterated, that with the prefrontal being the first to disappear. Upon the fore part of the palate (ib., fig. 3) the sutures remain between the premaxillaries (22) and the vomer (13), and between the premaxillaries and the contiguous palatine parts of the maxillaries (21).

I may here recall the remark made in discussing the homology of the 'prefrontals,'[2] viz., that the toothed Cetacea afford welcome and favorable grounds for determining the nature of the mammalian ethmoid through the absence of the olfactory sense-capsules which obscure the homologies of the prefrontals in the rest of their class. The 'os en ceinture,' Cuv., of Batrachians, and the similarly conspicuous rhomboid tract of the 'ethmoïde,' Cuv., on the upper and middle part of the base of the rostrum in Struthious Birds, exhibit the partially exposed condition of the prefrontals characterising certain species of *Ziphius*. In this, as in other Cetacea, the prefrontals, prior to their coalescence as 'lamina perpendicularis,' diverge and contribute a small share to the anterior wall of the cranium and a larger one to the posterior walls of the nasal passages, of which their produced and coalesced parts constitute the partition; they are connate posteriorly with the orbito-sphenoids, and usually coalesce with the vomer inferiorly. I have observed the coalesced 'lamina perpendicularis' to be cartilaginous in a young whale's skull where the rest of the walls of the nasal passages were ossified. The forward continuation of the 'lamina perpendicularis æthmoidei' rests upon the groove of the vomer, in a cartilaginous state, in most Cetacea, leaving the vacancy in the dry skull along the upper medial line which suggested to Cuvier the term 'cavirostris' for the *Ziphius* which he first made known to zoologists.[3] In the present species (*Z. Layardi*) it is ossified, and, becoming superficial and conspicuous between the premaxillary nasal processes, expands as it advances, and rises as a smooth,

[1] The want of definitions of bones or sutures in the descriptions and figures by Dr. J. E. Gray, F.R.S., of this instructive specimen, in the 'Proceedings of the Zoological Society,' April 11, 1865, p. 358, and in his very useful 'Catalogue of Seals and Whales in the British Museum,' 8vo, 1866, p. 354, has not enabled me to use or reproduce them for my present purpose.

[2] "On the Homologies of the Vertebrate Skeleton," 'Report of the British Association,' 1846, p. 226.

[3] The section of the skull of *Euphysetes simus* in my paper "On Indian Cetacea," 'Zool. Trans.,' vol. vi, pl. xiv, figs. 1, 10. 14. 13, will aid the student of homologies in following the above remarks.

dense, convex ridge (fig. 2, 14) an inch and a quarter across at its broadest part, gradually contracting to a breadth of half an inch when it has traversed one third of the length of the rostrum. At about the terminal third of this part the outer margin of what seems to be the suture between the prefrontal (14′) and premaxillary (22) rises and forms a free, thin, inwardly or medially bent margin of bone, which soon appears as the upper and outer border of a longitudinal canal, grooving the upper and medial surface of the premaxillary, and gradually gaining vertical extent as it passes forward. The under and inner margin of this groove is the, here, persistent medial suture or harmonia between the premaxillaries, which suture becomes obliterated at about one fourth of the way backward from the anterior end of the rostrum; and, thus, any definition of the boundary between prefrontals and premaxillaries becomes impossible. The solid terminal fourth of the rostrum, in advance of the vomer (13, fig. 3, Pl. I), is formed by the welded prefrontal and premaxillaries; behind this both bones, together with the vomer and the rostral parts of the maxillary (ib., 21), combine to form the dense beak-like production of the upper jaw, at the base of which are the palatines (ib., 20) and pterygoids (24).

On the palatal surface of the rostrum (Pl. I, fig. 3) the maxillo-premaxillary suture is distinct, or linearly traceable, and the vomer (13) intervenes between the contiguous palatal portions of the premaxillaries and maxillaries for an extent of one foot, gaining at the middle of this extent a breadth of 8 lines, and having a smooth transversely convex surface toward the palate. The degree in which the vomer thus appears upon the bony palate exemplifies, with other characters, a specific difference in *Ziphius* as in *Delphinus*.[1]

In *Phocæna brevirostris*[2] and *Euphysetes simus*[3] the limits of the prefrontals and of the vomer can be defined; the latter, in these and other *Cetacea*, is a long spout-shaped bone, its canal looking upward, and this receives, posteriorly, the anterior coalesced parts of the prefrontals, and, in advance thereof, the cartilage continued therefrom forward. This cartilaginous prolongation of the 'septum narium,' formed by the coalesced portions of the prefrontals, is ossified in the fossil kinds of *Ziphius* to be described, and projects conspicuously between the premaxillaries at the upper surface of the rostrum, as it does in *Z. Layardi*.

In this species the ectomaxillary groove (Pl. I, fig. 1, g') commences posteriorly between the antorbital plate of the maxillary (21′) and the pterygoid (24′), and is continued forward, diminishing in breadth and depth, upon the upper and outer border of the maxillary to the fore end of the rostrum, or of so much as remains in the present specimen, the extreme tip having been broken off. The lower boundary of the beginning of the ectomaxillary groove formed by the pterygoid and maxillary extends outward as a thick

[1] Compare, *e. g.*, the skull of *Delphinus* (*Steno*) *Gadamur* with that of *D.* (*Steno*) *frontatus*; or the skull of *Delphinus* (*Lagenorhynchus*) *fusiformis* with that of *D.* (*Lagenorhynchus*) *Pomegra*.

[2] Owen, "On Indian Cetacea," 'Trans. Zool. Soc.,' vol. vi, pl. ix.

[3] Ibid., pl. xiii.

convex buttress (*e*), some way beyond the upper boundary, subsiding, as it advances, at about the basal fourth of the rostrum. At about the middle of the rostrum the lower border of the ectomaxillary groove again projects, but as a sharp, somewhat jagged ridge; at the anterior third of the rostrum the upper part of the groove similarly projects, the lower one having subsided; such ridge or ridges I indicate as 'ectomaxillary,' but they evidently represent anteriorly the alveolar groove of toothed *Delphinidæ*. The interorbital plate of the maxillary is perforated by the two large apertures (*a*, *b*) for the transmission of nerves and vessels, answering to those marked *a* and *b* in Pl. IX (*Phocæna brevirostris*), Pl. XIII (*Euphysetes simus*) of my Memoir, above cited, on Indian *Cetacea*, homologous with the suborbital or antorbital division of the fifth nerve in land mammals. The fore part of the nasal processes of the premaxillary are also perforated by a smaller canal, whence a groove is continued some way forward along with the suture between the nasal plate of the premaxillary and the medial (prefrontal) part.

The outlets of the bony nostrils (Pl. I, fig. 2, *l*, *r*) are slightly twisted from behind forward and to the right, the right outlet (*r*) being the widest; the intervening septum shows a corresponding departure from symmetry. The posterior part of the premaxillaries (ib., fig. 2, 22) diverge, expand, and rise to define the cavity around the nostrils, or 'prenasal fossa,' as in all *Ziphii*.

The pterygoid is a broad, vertically extended, triangular plate of bone, widely and rather deeply excavated in the major part of its extent (fig. 1, 24'), the non-excavated anterior apex (24) being wedged between the maxillary and palatine at the lower and outer part of the base of the rostrum. The inferior thin border of the excavated part is slightly everted, and is applied to the corresponding part of the opposite pterygoid, leaving a deep fissure intervening and contracting posteriorly (ib., fig. 3, 24''). The breadth and depth of this 'interpterygoid fissure' varies in the species of *Ziphius*.[1] The conchoidal part of the petrotympanic is bilobed posteriorly, but less deeply indented than in *Delphinus*; it is rather widely open or unfolded anteriorly, with a thin, compact, involuted wall; the petrosal part articulates by a posterior process to the mastoid.

Being unable to draw the line of generic distinction at any of the gradations of length and slenderness of snout occupying, in this respect, the interval between *Ziphius indicus*, figs. 4—7, and *Ziphius Layardi*, Pl. I, and meeting the same difficulty in the degrees in which the prefrontal cartilage of the rostrum becomes ossified, I hold by the well-defined characters of the Cuvierian genus; and, premising the above definitions of recognisable parts of the Ziphial rostrum, I proceed to apply them to the specific definition of the petrified snouts from the 'Red Crag.'

[1] It is wide, *e. g.* in *Ziphius patachonicus*, pl. xvii, fig. 2, *h h*, of Burmeister, 'Anales del Museo publico de Buenos Ayres,' 4to, 1868.

Genus—Ziphius, *Cuvier*.[1]

Species—Ziphius planus, *Owen*. Plate II, fig. 1.

This species is represented by the basal part (probably third) of the rostrum, including the fore part of the right (*r*) and left (*l*) prenasal channels or fossæ, leading from the nostrils to the 'premaxillary' grooves or canals (*d, d*). These concavities present the same unsymmetrical twist as in *Ziphius Layardi* (Pl. I, fig. 2, *r* and *l*), *Z. planirostris* (fig. 2, 22′, 22′), and *Z. Cuvieri* (fig. 3). The disproportionate breadth of the right prenarial channel (Pl. II, fig. 1, 22′, *r*) is greater in the fossil. The correspondingly bent prefrontal septum (14, 14) is relatively thicker than in *Z. Layardi*, and is more directly continued into the mid-tract (14′), which is flatter above, than in the recent species, resembling in that respect *Ziphius Cuvieri* (fig. 3). The premaxillary grooves (*d, d*) continued forward from the fore ends of the prenasal fossæ (*r, l*) show, at their commencement, the orifice of a small canal, as in *Ziphius Layardi*, leading into the osseous substance of the rostrum. The prenasal grooves soon subside. The intermediate prefrontal tract is continued on flattened above, not convex, as in *Z. Layardi*, but the generic resemblance is well marked. The posterior part of the maxillaries include the large anterior nervo-vascular (antorbital) foramen (*b*), and show the posterior beginning of the ectomaxillary groove (*g, g*), the upper border of which is developed to form the ectomaxillary ridge (*e, e*); this speedily subsides. The superiorly flattened mid-tract (14′, 14′) slightly expands toward the fractured fore end of the rostrum, where its lateral boundaries sink into wide and shallow longitudinal channels. The worn surface of the under part of this rostral fragment yields no satisfactory character.

The upper surface of the fossil is represented of the natural size (Pl. II, fig. 1), and indicates a species of *Ziphius* larger than the *Z. Layardi*. The vertical diameter of the rostrum, at *i*, is 4 inches.

The specimen was found in the Red Crag at Shotley, Suffolk, and had been split, lengthwise and vertically, by a workman, the fissure extending from the right prenasal fossa to the middle of the mid-tract (14′, 14′).

[1] Synonyms:—*Epiodon, Diodon, Heterodon, Dioplodon, Alaima, Delphinorhynchus, Petrorhynchus, Dolichodon, Micropterus* and *Micropteron, Mesoplodon, Mesodiodon, Ziphiopsis, Placoziphius, Aporotus, Ziphirostrum, Rhinostodes, Berardius, Hoplocetus, Eucetus, Ziphiorhynchus, Choenodelphinus, Choenocetus, Belemnoziphius*, &c. (the mob is included in the family *Rhynchoceti*, Eschricht).

It is completely petrified, and yields on percussion the clear metallic ringing sound characteristic of the Cetacean fossils from this formation; but it is less deeply stained by ferrugineous salts than is commonly seen in the fossil snouts from other Suffolk Red Crag localities.

Species—ZIPHIUS GIBBUS, *Owen*. Plate II, fig. 2; and Plate III, fig. 3.

Amongst the fossil, as in existing, *Ziphii* are some species with an excessive development of the 'mid-tract' in the upper surface of the rostrum.

I propose the specific term '*gibbus*' for one of the 'Red Crag' snouts, because the mid-tract is not only convex transversely (Pl. II, fig. 2, 14′, 14′), but rises by a more defined and elevated longitudinal convexity (Pl. III, fig. 3, 14′) than in the other fossil species.

In the specimen exemplifying this character—the subject of the figures cited—a smaller portion of the fore part of the prenasal fossæ (Pl. II, fig. 2, 22′) is included than in *Ziphius planus*. Sufficient of the fore part of the 'septum narium' (ib., fig. 2, 14) is preserved to indicate an unsymmetrical twist to the left, and also to demonstrate that such part of the bony septum is absolutely thicker than in the larger existing species, *Ziphius Layardi*, and that it is thinner both absolutely and relatively than in *Ziphius angustus* (Pl. III, fig. 2). It expands, in *Ziphius gibbus*, immediately beyond the nostrils, and rapidly, into the 'mid-tract' (14′), which gains, with some excess on the right side, a breadth of one inch at twice that distance from the nostrils, then gradually narrows to three fourths of an inch, and again expands both transversely and vertically to the extent shown in the figures cited. The subsidence, longitudinally, to the fractured fore part of this rostrum is more rapid than the rise, and that, as it appears, without any mechanical influence of posthumous abrasion (Pl. III, fig. 3). The proportion of the upper surface of the rostrum contributed by the narrower part of the mid-tract (14′), at the point marked by the star in fig. 3, is shown in the outline of the circumference at that part (drawn with the upper part downward) in Pl. III, 14′; the much larger proportion which, through its own expansion and the subsidence of the side tracts of the premaxillaries (22), the mid-tract (14′) forms at the part of the rostrum marked by the star in Pl. II, fig. 2, is indicated at 14′, 14′ in the superadded outline of the transverse section at that part of the rostrum.

The nasal processes of the premaxillaries (22′, 22′, fig. 2, Pl. II) are perforated, each by an orifice (*d*) relatively wider than in *Ziphius Layardi* (Pl. I, fig. 2, *d*); and no groove is continued forward from the 'foramen naso-premaxillare' (*d*) in *Ziphius gibbus*, as is the case in *Ziphius planus* and *Ziphius Layardi*.

The commencement of the interorbital expanse of the maxillary (21, fig. 2, Pl. II) in

Ziphius gibbus shows the nervo-vascular foramen (*b*, *b*) on nearly the same transverse line as *d*, *d*; the downward and backward direction of the canal leading therefrom to the common entorbital foramen[1] is shown at *d*, fig. 3, Pl. III.

The pterygoid alæ (Pl. III, fig. 3, 24) would seem to be directly applied to the under part of these maxillary expansions, and not to be separated therefrom by the fissure seen in *Ziphius Layardi* (Pl. I, fig. 1, between 21′ and 24′); but on this point the abraded condition of the hinder end of the rostrum makes it unsafe to insist. It appears certain that the representative of the ectomaxillary ridge (Pl. II, fig. 2, 21...*e*, and Pl. III, fig. 3, *e*, *eg*) is much thinner vertically than in *Ziphius Layardi*, and more rapidly subsides as it advances forward upon the side of the base of the rostrum. A narrow ectomaxillary groove (Pl. III, fig. 3, *eg*) is continued forward from the point of subsidence to the broken end of the snout, gradually sinking toward the lower part of the snout, as in *Ziphius Layardi*. No sutural evidence of the proportions of the maxillary and premaxillary bones remains upon the sides of the rostrum under description. Neither, though there be an indication of the structure, can it be certainly affirmed that the veritable vomer contributes any proportion of the smooth, transversely convex under surface of the rostrum, the curves of which, in transverse section, are indicated in the outlines taken at the two points marked in Pls. II and III.

A medial linear suture marks the meeting of the palatal plates of the maxillaries, anterior to the palatine bones, as in *Ziphius Layardi* (Pl. I, fig. 3, 20), and this line can be traced inclining to the right side, as in the right vomero-maxillary suture in *Z. Layardi*, but the left one is obliterated, if it existed, in *Ziphius gibbus*. The medial plates of the pterygoids have met and been in contact for a greater extent in *Ziphius gibbus* than in *Ziphius Layardi*, descending to form a deep median angular ridge, to the fore part of which the palatines seem to have contributed some share. But here, again, the state of abrasion affects the utility of further attempts to specify structural characters.

Sufficient, however, of the present rostrum has defied the effects of long ages of surf-movements, through the degree of petrifaction undergone before dislodgment from its original burial-bed, to justify the specific distinction attempted to be pointed out, and, at all events, to afford means of comparison which may lead to a reference of other specimens of Crag-whale-snouts to the *Ziphius gibbus*.

[1] Shown at *d*, fig. 2, pl. 13, 'Indian Cetacea,' loc. cit., in *Euphysetes simus*.

Species—ZIPHIUS ANGUSTUS.

ZIPHIUS ANGUSTUS, *Owen*. Plate III, figs. 1 and 2.

The snout on which a species of *Ziphius* is indicated by the above name exhibits a development transversely and vertically of the prefrontal mid-tract (14′, 14′) similar to that in the foregoing species, but it is not identical; the convex mid-tract is relatively narrower, as is the rostrum itself, in *Ziphius angustus*, and the narrower part of the tract, after its slight hinder expansion, is of greater longitudinal extent before its second or anterior expansion. The whole rostrum is more slender, as is indicated by the contour of the transverse section given in Pl. III, at the part marked with the star in figs. 1 and 2, which corresponds with the part of the rostrum similarly marked in *Ziphius gibbus* (ib., fig. 3). Moreover, the ectolateral maxillary ridge (ib., fig. 1, *e*, *e′*) is longer, extending further forward upon the side of the rostrum, and subsiding more gradually.

The premaxillary foramina (*d*, *d*, fig. 2) are as large as in *Ziphius gibbus*. Only the inner walls of the maxillary foramina (*b*, *b*, 21, fig. 2) remain; they show them to be on the same transverse line as *d*, *d*, but to be nearer thereto, indicative of a continuance of the slender character of the snout to this commencement of the maxillary platform. The ectomaxillary groove (ib., fig. 1, *eg*) is narrow, and extends forward, descending, as in *Ziphius gibbus;* but its lower border begins to swell outward (*e′*, 21, fig. 1) as it gets toward the fore end of the present fragment, as in *Ziphius Layardi*, indicating that one half or more of the rostrum may be wanting in the present specimen. The sides of the pterygo-palatine ridge are slightly concave in *Ziphius angustus*, at the part where they show a moderate convexity in *Ziphius gibbus*, and it is improbable that this difference can have been caused by posthumous abrasion.

The specimen described is figured of the natural size in the two views given in Pl. III, figs. 1 and 2.

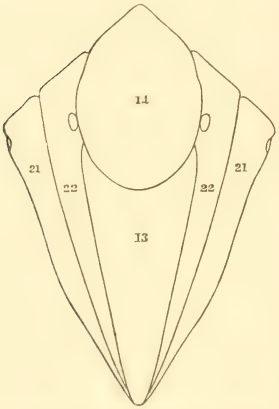
The density of the bony texture of the fractured fore part of the snout closely accords with that of the same part in the recent *Ziphius Layardi*, and suggests an application, by the living animal, of the snout analogous to that of the similar rapier-like rostral weapon in the Sword-fish (*Histiophorus*).

Species—ZIPHIUS ANGULATUS.

ZIPHIUS ANGULATUS, *Owen*. Plate IV, figs. 1 and 2.

In this well-marked species the prefrontal mid-tract rises in an angular roof-like manner, the sides of the upper surface of the rostrum so formed sloping from a median ridge at the angle shown in cut, fig. 9, and in the section below fig. 1 in Pl. IV. In this specimen the maxillo-premaxillary suture (*s* in fig. 1) is traceable at the expanded basal part of the rostrum, showing the proximity thereto of the (antorbital) nervo-vascular canal (*b*) in the beginning of the expanded part of the maxillary bone. The premaxillary foramen (*d*) is midway between that suture and the prefronto-premaxillary suture; this foramen is smaller than in the two preceding fossil species, and in the same degree approaches to the character afforded by the foramina (*d*, Pl. I, fig. 2) in the recent *Ziphius Layardi*. The septum narium (14) rapidly expands, anterior to the nostrils, to the breadth of the mid-tract shown in fig. 1, at two inches in advance of the nostrils. From this part the mid-tract advances, maintaining the same breadth to the middle of the rostrum, and thence gradually contracts, with subsidence of the roof, to the broken anterior end. The right premaxillary shows a superficial groove (*v*, *v*) about four inches long, near the margin of the mid-tract, due to a branch of the main canal (*d*). The corresponding canal, exposed by the fracture at *v'*, in the left premaxillary, ran deeper, and its superficial branch emerged later or further forward upon the surface. The ectomaxillary ridge of the snout (fig. 2, *e*), commencing at the outer and lower wall of the canal (*b*), extends forward, gradually subsiding, but not to effacement, in the preserved extent of the present rostrum, at least on the right side; on the left side it is interrupted at its middle part by the emergence of a branch canal from *b*, forming an open narrow groove for two or three inches, beyond which the ridge, though lower, is resumed.

FIG. 9.



Section of rostrum, *Ziphius angulatus*.

The sides of the pterygo-palatine keel-like ridge (fig. 2, 24) is almost flat; anterior to this the lower and lateral parts of the snout show two successive slight swellings, as at *y* and *z*,

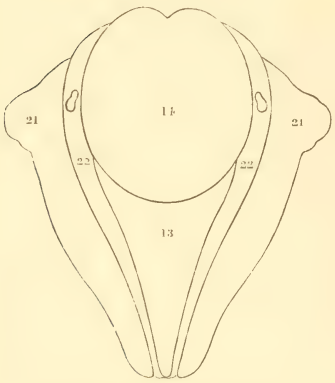
fig. 2; and the lower or palatal contour rises toward the upper line of the snout, and this in a way that seems not to be due to friction. The post-palatal ridge, due to the confluence of the medial plates of the pterygoids (fig. 2, 24′), forms a deep and sharp carina. In advance of this the vomer appears upon the palate, forming the keel of the ridge there; the composition of the rostrum at this part is shown in fig. 9, where 14 is prefrontal, 13 vomer, 21 maxillary, 22 premaxillary.

Species—ZIPHIUS MEDILINEATUS.

ZIPHIUS MEDILINEATUS, *Owen*. Plate IV, fig. 3.

In the by no means easy task of choosing a name from specific characters shown by this class of fossils, I have been led to the one above given by the extent to which such mid-line, indicative of a bipartition of the mid-tract (14′, 14′), extends along that tract in the present specimen. It is present in a feebler degree and for a less extent in another specimen, afterwards to be described, which may indicate a variety of the present species, but such character of the mid-tract of this species is not the only one by which it differs from the foregoing *Ziphii*.

FIG. 10.



Section of rostrum, *Ziphius medilineatus*.

With reference to the character of the largest and first-described specimen, suggesting for it the name *planus*, it might be objected that a convexity of the mid-tract, as shown in *Z. gibbus*, had been worn down by posthumous abrasion. So, likewise, it may be said of the present species, that the persistence of the median line is due to the nonage of the individual. But, if so, it coexists with a flatness of the part of the prefrontal mid-tract along which it extends that cannot be the result of abrasion, for the sides of the longitudinal fissure are convex; and yet the degree of convexity is so slight on each side of the fissure that the mid-tract gives as flattened a character of the upper posterior part of the snout as in *Ziphius planus*. I conclude, therefore, that the difference in the character of the mid-tract between the present species and *Ziphius angustus*, *Z. angulatus*, *Z. gibbus*, to be due to an original and inherent structural specific character of the skull in *Ziphius medilineatus*. From *Ziphius planus* it differs not only in size, but in the greater degree of transverse convexity of the upper part of the snout between the fore parts of the ectolateral ridges *e*, *e* (as, *e. g.*, at the place, *, of the section figured below fig. 3, Pl. IV), and in the greater relative longitudinal extent of those ridges; there is not, besides, any trace in *Z. planus* of the median linear groove characteristic of the prefrontal tract (14′, 14′, fig. 3) in the present species. The short oblique irregular fissure on the outside of 14, in fig. 3, simulates a suture defining the prefrontal from the mid-tract, as the mid-line along that

tract simulates a sutural division of the tract itself; but the one is due to fracture, and the other to a linear groove, which groove gradually becomes shallower, and is obliterated at six and a half inches from the internarial part of the prefrontal. The linear grooves (22, 22, fig. 3) dividing the mid-tract from the lateral parts of the premaxillaries disappear about the same part of the snout with such mid-groove. The ectomaxillary ridge (*e*, *e*) rather suddenly decreases about three inches from its basal beginning, but is continued forward four inches before it finally subsides; a narrow groove extends forward in the same direction to the fractured fore end of the snout. The median fissure between the descending pterygoid plates is conspicuous in the present species; they seem not to have coalesced so completely as in the palatal carina so formed in previous species. An inferior median 'vomerine' tract is indicated by parallel longitudinal grooves along the anterior two inches of the palatal surface of the present specimen. The constituents of the rostrum at this part are marked in fig. 10 by the same numerals as in fig. 9.

Species—ZIPHIUS TENUIROSTRIS, *Owen*. Plate V, figs. 1 and 2.

The first, or basal, five inches of the prefrontal mid-tract in this specimen is more convex than in *Ziphius planus* or *Z. medilineatus*, but is less convex than in *Z. gibbus* or *Z. angustus*.[1] Beyond that point (*, fig. 1) the mid-tract rises with a well-marked transversely convex surface, and with a slight longitudinal convexity, after which it is continued straight to the fractured fore end of the snout, preserving its transverse breadth and convexity, as well as the lateral linear grooves or sutural indications of distinction from the side-plates of the premaxillaries (22). These plates descend from those sutures almost vertically, with a slight outward expansion, to join or coalesce with the maxillaries (21) in the extent of the snout preserved anterior to the ectomaxillary ridges. These ridges (Pl. V, figs. 1 and 2, *e*, *e*), when in advance of the intraorbital expansion of the maxillaries, are continued forward for ten inches before final subsidence, the decrease of breadth being very gradual. At about eight inches from their origin the nervo-vascular canal, of which the ridge *e* at first forms the outer wall, emerges, the ridge itself being then continued onward as the lower border of that canal. The high position of the basal half of the ridges makes them seem to terminate laterally the upper surface of that part of the rostrum, the transverse contour of which upper surface is sinuous, moderately convex at the middle, and concave on each side, as shown in the section at 14′, 14′, and *e*, *e*′, Pl. V, but in a minor degree than at the more basal parts of the rostrum. The side of the rostrum below the ectomaxillary ridges swells into a longitudinal convex tract (*m*, fig. 1, Pl. V). The vomer, emerging upon the palate, about half way from the inner end, of the present specimen (fig. 1, 13) contributes about half an inch of its transverse extent to the fractured fore part, indicating, according to the analogy of *Ziphius Layardi* (Pl. I, fig. 3) that this long and slender form of snout must have extended about six inches beyond the fractured fore part of the specimen above described.

[1] Compare the section at the point *, in fig. 1, Pl. V, in regard to the convexity of 14′, 14, with that part in the section below fig. 3, Pl. IV, or the sections given in Pl. III.

Species—ZIPHIUS COMPRESSUS, *Owen*. Plate V, fig. 3.

The differential character of the present species is shown by the predominance of the dimension of depth over that of breadth at every part of the extent of the specimen figured. The prefrontal mid-tract (14′, 14′) is transversely convex from its beginning, the convexity increasing as it advances; and, from the low position of the ectomaxillary ridges (*e*, *e*) and the steep slope thereto of the premaxillaries (22), the mid-tract seems, of itself, to constitute the upper surface of the rostrum, almost in the degree shown at the part *, fig. 3, the transverse section of which is given below that figure. The upper part of the mid-tract is impressed by a median linear groove, filled up about four and a half inches from the base of this rostral fragment. But the difference in form and proportion from *Ziphius medilineatus* is strongly marked, and is exemplified in the section outlined in the two species in Pls. IV and V.

On both sides of the rostrum of *Ziphius compressus* the nervo-vascular canal continuous with the ectomaxillary ridge (Pl. V, fig. 3, *e*) is exposed, its more prominent lower border representing the continuation of the ridge. The surfaces below the ridges converging to the pterygoid carina are almost flat. The figure between the pterygoid plates is unobliterated, though narrow. The palatal surface is transversely convex in advance of the carina, expanding to the breadth shown at the part whence the section is taken below (fig. 3). In this respect *Ziphius compressus* markedly differs from *Z. medilineatus* and *Z. angulatus*. The proportion contributed by the vomer to the palatal surface is much the same as in *Ziphius tenuirostris;* the disposition and proportions of the other constituents of the rostrum, here, are similar to those denoted by the usual numeral symbols in the woodcut, fig. 6. The upper and fore part of the present specimen of *Ziphius compressus* has been subject to an abrading action, which seems to have shaved off, obliquely downward and forward, a deep line from that surface: the sloping contour (14′, 22′) shown in fig. 3, Pl. V, is due to that accident.

REMARKS ON RECENT AND FOSSIL ZIPHIOID CETACEA.

DOLICHODON, *Gray*.—According to the practice—principle I have in vain endeavoured to discover—whereby genera have been founded on, or generic names given to, recent and fossil Ziphioid Cetaceans, as many genera as species might have been made out of the fossil snouts selected from the fruits of many years' gathering and observation of such, in order to exemplify what, on the assumption of transmissibility of such characters, I take to be specific departures from a primitive ziphioid type.

The claims of *Ziphius Layardi*, for example, to the generic distinction conferred on it, under the name *Dolichodon*, appear to rest on modifications of the mandibular pair of teeth, which are described as "very long, produced, arched, and truncated, with a conical process in front."[1]

I have figured the obtusely rounded extremity of the left of these teeth of the natural size, in Pl. I, fig. 5. The first calcified part of the tooth-pulp, which still retains a thin coat of enamel, must have appeared as the 'germ' of the tooth in the young *Ziphius*, and was probably one of a series in the alveolar groove. Its formation in the present tooth has been followed by a rapid growth of matrix in the antero-posterior direction, which became calcified without enamel, and was progressively added to from below until, finally, a tooth of 1 foot in length, 1½ inch to 2 inches in fore-and-aft breadth, and from 3 lines to 6 lines in thickness, was completed, and most probably, as a sexual character. In the present specimen about three inches of the base of the tooth is obliquely inserted into a cleft of the alveolar border of the mandible (*c*, *c*, fig. 4, Pl. I); the base of the tooth terminates in a solid jagged border, showing exhaustion of the pulp and cessation of further growth, but abrasion of the fore part of the base of the exposed crown of the tooth has exposed a shallow remnant of the pulp-cavity. This abrasion seems due, as Dr. Gray observes, to "friction of the upper jaw."[2] The dense rostrum rested in part thereon when the mouth is closed, and the teeth curved backward and inward so as to embrace the rostrum, as shown in Mr. Trimen's drawing,[3] reproduced by Dr. Gray in his 'Catalogue' above cited.

Many teeth of *Cetacea* from the Red Crag have reached me showing abrasion of the dentinal part or body of the tooth below an apical or coronal part, on which a thin layer of enamel is traceable. The analogy of the structure of the mandibular teeth of *Ziphius Layardi* supports a reference of such Crag fossils to the same genus, and I have observed nothing in the anterior laniariform teeth of *Zeuglodon* (or *Squalodon*) to affect such view.

It is probable that the mandibular teeth, developed as in *Ziphius Layardi*, are peculiar to the male, but the proof is wanting. It is more probable that they exhibit an abnormal direction and state of growth in the specimen figured in Pl. I. In any case I cannot regard such modifications of form or size of the pair of laniariform mandibular teeth, characteristic of *Ziphius*, Cuv., as grounds for further splitting up this well-marked and intelligibly defined genus.

Petrorhynchus, *Gray*.—It will be seen that I have availed myself of the various degrees

[1] Gray, 'Catalogue of Seals and Whales in the British Museum,' 8vo, 1866, p. 353.

[2] Ib., p. 355. Dr. Gray's expression, "The edges of the front lower teeth are absorbed or worn away," &c., would leave the inference that there were other teeth behind, which is not the case; he doubtless meant to say "the front edge of the lower teeth," but it is a small part only of that edge which is so affected.

[3] 'Proc. Zool. Soc.,' April 11, 1865, p. 358, fig. *e*.

and forms in which the cartilage continued forward from the prefrontal 'septum narium,' and resting upon the groove of the spout-shaped vomer, has been ossified in our Red Crag *Ziphii*, to indicate their 'specific' distinction. Dr. Gray uses this character in the case of *Ziphius indicus*, in which the cartilage called by its definer, Van Beneden, "cartilage vomérienne" is ossified, and in the nearly allied, if not identical, species, showing, also, ossification with superior convexity of the 'mid-tract' (figs. 4, 5, 14'), to support the imposition of the generic name '*Petrorhynchus*.' I am disinclined, however, to refer my *Ziphius gibbus*, with the like modification of Van Beneden's 'cartilage vomérienne,' to that nominal genus.[1]

Having given careful and impartial consideration to the characters which have been proposed, or allowed to be inferred, as those of generic value in other instances, I crave leave to continue, in reference thereto, to submit the reasons for a different estimate of such characters.

Epiodon, *Rafinesque* (*Schmaltz*).—One of the characters assigned to this genus by its founder appears to have been due either to anomaly or to accidental mutilation of the individual:—"Sous-famille. Point de nageoire dorsale. G. 1, *Catodon*, Lac. 2, *Notaphrum*, R. do., sp. 3, *Epiodon*, R.," &c.[2] The dorsal fin is characteristically small in *Ziphius*, but is never, normally, wanting. Rafinesque's genus has been subsequently accepted with rectification of the fin-character, and the addition of a dental one,[3] founded on the position of the characteristic mandibular pair of teeth, viz. 'in front of the lower jaw,' or near the anterior end of the symphysis, and on some modification of the shape of those teeth,

[1] "In *Ziphius* ossification extends along the cartilaginous continuation of the prefrontals forward to near the end of the premaxillaries."—"Report on the Archetype and Homologies of the Vertebrate Skeleton," 'Report of British Association,' 8vo, 1846, p. 226. I have been gratified by seeing, at length, this homology recognised, and trust we shall hear no more of the vomer appearing upon, or occupying any part of, the upper face of the cetacean rostrum. "Les fosses nasales étant refoulées à la base du crâne, les maxillaires avec les intermaxillaires et le vomer forment une masse compacte de trois os emboités, au centre desquels on trouve ordinairement la partie cartilagineuse de l'æthmoïde qui termine en avant la colonne vertébrale." "Rarement ce cartilage est ossifié: nous n'en connaissons des exemples que dans les ziphioïdes."—Van Beneden and Gervais, 'Ostéographie des Cétacés, vivants et fossiles,' 4to (texte), fol. (planches), p. 4: no date; but the first Part, with pls. i, ii, xxi, xxiii, was received by me Nov. 2, 1868.

[2] 'Analyse de la Nature,' &c., 12mo, Palerme, 1815, p. 60.

[3] Gray, 'Catalogue of Seals and Whales,' 8vo, 1866, p. 340. The Author quotes "Rafinesque, Précis Somiol. 13, 1814 (no character)," op. cit., p. 341; but the latter remark would apply more truly to the genus *Kogia* proposed in the 'Zoology of the Erebus and Terror,' "Cetacea," 4to, 1846, p. 22; with the additional remark by Rafinesque, "les noms trop barbares doivent être modifiés," 'Principes fondamentaux de Somiologie,' &c., 8vo, 1814, 'Règles Génériques,' No. 41, p. 30. It may not be out of place to quote the following from the same judicious Naturalist of Palermo:—"Il est absurde d'indiquer ou établir un Genre, sans lui assigner des caractères, puisque ces caractères en sont les bases génériques et que sans différences charactéristiques il ne pourrait exister réellement; on doit en conséquence les exprimer par une définition, toutes es fois que l'on indique un Genre nouveau, sans quoi autant vaudrait ne pas tantaliser la curiosité en mentionnant son vain nom."—Op. cit., p. 19. I have that confidence in the common-sense and

respecting which I may first remark that each of such teeth is lodged in an elongate fissure at the fore part of the alveolar border, as in *Ziphius Layardi*. The mid-cartilage, supported by the vomer and continued from the prefrontal septum, does not become ossified, and consequently the bony rostrum appears to be excavated above. This character is signified, according to its true value, by the specific term *cavirostris*, applied by Cuvier to a form or species of *Ziphius* still represented in European seas. Nor does the dental modification appear to me in any measure to justify generic distinction. To the trouble of cetologists, however, the *Ziphius cavirostris* of Cuvier has to sustain, not only the generic term *Epiodon*, put upon it by Rafinesque, but also those of *Heterodon* (by Lesson), of *Dioplodon* (by Gervais), of *Alaima* (by Gray), &c.

Delphinorhynchus, *De Blainville*.[1]—This name was imposed upon a Cetacean, 15 feet in length, stranded at Havre, September, 1825, having a rostriform termination of the upper jaw, without conspicuous teeth, and with one pair of teeth at the symphysial part of the lower jaw. The rostrum was composed of vomer, maxillaries, and premaxillaries, the latter apart at their upper margins, and enclosing a cartilaginous prolongation of the prefrontal, resting upon a canaliculate vomer; the basal parts of the premaxillaries, diverging and expanding posteriorly, rose to define and include a prenasal fossa, bisected by an ossified prefrontal septum, and at the back part of which the nostrils opened. Palatines and pterygoids contributed to form the under part of the base of the rostrum.[2]

All the characters of *Ziphius* (Cuvier, 1823), with the main specific modifications of the cavirostral species, are here manifested. The real gain to zoology was the opportunity of defining the external characters of the entire recent representative of the genus which the Founder of Palæontology believed to have become extinct. This specimen was unfortunately applied to multiply useless names and divert from the completion of a knowledge of a most interesting generic form, ably and sagaciously indicated by Cuvier; it will again be referred to in reference to the claims for acceptance of the genus *Mesodiodon*.

good judgment of my fellow countrymen and labourers in philosophical zoology which leads me to anticipate a tacit burial and oblivion of the barbarous and undefined generic names with which the fair edifice begun by Linnæus has been defaced.

[1] 'Bulletin de la Société Philomathique,' tom. iv (1825), p. 139.

[2] F. Cuvier, 'Hist. des Cétacés,' 8vo, p. 116, pls. vii and viii, fig. 1.

Genus—Berardius, *Duvernoy*.

Fig 11.

Skull of *Ziphius* (*Berardius*) *Arnouxii*, Duv.

This genus was founded by Duvernoy[1] on the head or skull of a *Ziphius* brought from the 'mers de la Nouvelle Zélande' by M. Arnoux, chirurgien-major of the corvette *Le Rhin*, commanded by Capt. Bérard, and presented by him to the Museum of Natural History in the Garden of Plants in 1846. The animal is stated to have been stranded at Port Akaroa, Banks' Peninsula, New Zealand. It was about 32 feet in length, and the skull (fig. 11) measured 4 feet. The cranium is rather more symmetrical than usual, and shows, as in *Ziphius indicus*, a beginning of the vertical productions of the maxillaries (*e*) which distinguish, by their full development, the genus *Hyperoodon*.

The premaxillaries (22, 22′) are divided along the upper part of the rostrum by a channel (originally occupied by the unossified basis of the prefrontals), exposing the upper groove of the vomer, and giving to the transverse section of the rostrum a deep upper emargination ("la forme demi-cylindrique," Duvernoy, ib., p. 53).

The prenasal fossæ (fig. 11, 22′) contract forward to the entry of the incisive or naso-premaxillary canals (*d*), as in *Ziphius planirostris*, Cuv. (fig. 2, *d*, *d*, p. 5). In the non-ossification of the prefrontal cartilage, *Ziphius Arnouxii* participates with *Z. Gervaisii*, *Z. micropterus*, and *Z. patachonichus*. The anterior (*c*) of the three outlets (*a*, *b*, *c*) of the sub-orbital or antorbital canal opens into a better defined depression of the maxillary (at *c*, fig. 11) than usual, but this cannot be interpreted as generic. The ecto-maxillary ridges (*e*) have a rugous exterior,[2] as in *Ziphius Cuvieri* (fig. 3, p. 6). The vomer 'puts in an appearance' at the under surface of the rostrum, between the maxillaries and pre-maxillaries, for an extent of about 1 foot 3 inches. Herein *Z. Arnouxii* resembles *Z. Layardi*, but combines the character with a non-ossification of the prefrontal rostral cartilage. The mid-pterygoid keel shows a fissure due to non-confluence of the descending plates. In all these characters we have specific modifications of an essentially generic ziphial type. The value of the mandibular dental character will be discussed in connection with the next nominal genus.

Mesodiodon, *Duvernoy*.—The chief character of this genus is the position of the developed pair of mandibular teeth (figs. 12 and 13).[3] On this character I would remark that more than one pair of teeth or of gingival tooth-germs are formed in the alveolar

[1] 'Annales des Sciences Nat.,' 3e série, "Zoologie," tom. xv, pl. i.

[2] Are these the parts defined as "*intermaxillaries, rather swollen on side of blowers*," in Gray, 'Catal. of Seals and Whales,' 8vo, 1866, p. 327?

[3] "III. Le genre *Mesodiodon*, nob., caracterisé par l'existence de deux dents développés et alvéolaires à la mâchoire inférieure, qui sont implantées bien en arrière de celles du genre précédent, à peu près au commencement du second tiers de la longueur de chaque branche mandibulaire. Ce genre, distingué d'ailleurs par d'autres caractères importants, se compose de quatre espèces, dont trois vivantes et une fossile."—Duvernoy, loc. cit., p. 41.

groove of the immature *Ziphii* in both upper and lower jaws. But of these rudimental teeth the mandibular alveolar pair, calcified and developed, in sexual or other relations, is not the same in every species. Then arises the question, Is the difference of place—in one a little further forward (figs. 8 and 11), in another a little further backward (fig. 12, and Pl. I, fig. 4)—significant of those general or wider modifications of structure which alone justify, alone make usefully applicable, a generic section of mammals with its distinctive appellation? As a physiologist, or guided by common-sense, I cannot admit such interpretation of value of an almost functionally insignificant character, yielded by parts also which are the seat of such great and singular variability in the Cetaceous order.

Sometimes two pairs of this series of rudimental mandibular teeth are developed, as in *Hyperoodon*, Lacép. In Hunter's specimen (from 30 to 40 feet long, No. 2479, Mus. Coll. Chir.), as in that figured in my 'Odontography,' pl. lxxxviii, fig. 1, 1, 2, the two teeth in each ramus are approximate, and the anterior one is much the smallest; in Lacépède's specimen (a male, 22 feet long) they are further apart, the foremost answering to the second more developed tooth in No. 2480, Mus. Coll. Chir.

In the *Ziphius* from New Zealand (fig. 11) two teeth are developed in the same position in each ramus as in *Hyperoodon Butzkopf*, Lacép. (*H. Baussardi*, F. Cuv.). Thereupon is proposed the genus *Berardius*. Duvernoy remarks—"Il a, entre autres, pour caractère quatre fortes dents triangulaires comprimées à l'extremité de la mâchoire inférieure" (loc. cit., p. 41). But the term 'à l'extremité' would apply more accurately to Hunter's Ziphioid than to Arnoux's.

As to the inadequacy of this dental character of two pairs attaining calcification and a certain degree of growth, the same remark applies as to the generic importance of the accident—for it can hardly be called otherwise—whether the fore or the hind pair of such teeth rest rudimentary.

Of any other generic characters ('entre autres') of his *Berardius* Duvernoy is silent.

Assuming the minor degree of symmetry in the naso-maxillary part of the skull to be constant in the species, and not an individual variety, on what intelligible ground can such small modification of form and direction in bones, confessedly presenting in all essential respects the characters of other *Ziphii*, sustain the imposition of a generic name?

The intermediate step, shown by *Ziphius Arnouxii*, in the development of the parts of the maxillaries (fig. 11, *e*, *e*), which forms, perhaps, in its extreme degree, the best reason for accepting *Hyperoodon* as a nominal indication of the species of Ziphioids with such fully developed processes, is significant of the derivative bond uniting all the Ziphioid family.

Fig. 12 represents the skull of a *Ziphius*[1] stranded near Havre, at the mouth of the Seine, which is said by Suriray to have shown four parallel longitudinal furrows in the skin of the throat, about half an inch deep.

Fig. 12.

Ziphius microplerus.
(*Mesodiodon microplerum*, Duv.)

It would be well to look for this structure in other recently stranded *Ziphii*.[2] It may be a distinctive character, but would then be cutaneous and specific—nothing more.

Compared with *Ziphius Sowerbii*, *Z. micropterus* is longer and more slender. The base of the premaxillary (22') shows the infundibular expansion of the beginning of the naso-premaxillary canal (*d*) (as in *Ziphius planirostris*, Cuv.).[3]

The rostral parts of the premaxillaries are separate above, the ossification of the prefrontal gristle not extending beyond the part marked 14, in advance of which is exposed, as usual, the deeply situated canaliculate surface of the vomer which supported the cartilage.

The maxillaries (21) show one large (*b*) and several small nervo-vascular outlets (*a*—*c*) and the lateral ridge (*e*).

[1] This skull, ascribed to a genus *Delphinorhynchus*, is described as the type of the *Delphinidæ* in the 'Histoire Naturelle des Cetacés' of Fr. Cuvier, 8vo, p. 75 et seq.

[2] Dr. Gray ascribes to the *Ziphius* (*Delphinorhynchus*) *micropterus* stranded at Ostend in 1835 the character of "throat with four parallel slits beneath" ('Catalogue of Seals and Whales,' 8vo, 1866, p. 352); but I do not find this noticed in the memoir by Dumortier, 'Mémoires de l'Académie Royale de Bruxelles,' tome xii, containing the only description of this recent *Ziphius* with which I am acquainted. The incidents ascribed by Gray to "the female caught at Havre, on the 22nd August, 1828" ('Catal. of Seals and Whales,' p. 352), are suspiciously like those narrated by Dumortier of his Ostend specimen:—"Sa longueur totale, depuis l'extrémité du museau jusqu'à celle de la queue, était 3 mètres 45 centimètres, ou environ 11 pieds." "Le Delphinorhynque d'Ostende fut conservé vivant hors de l'eau pendant deux jours, mais sans rien vouloir manger. En vain voulut on lui offrir du pain humecté et d'autres substances alimentaires, il les refusa constamment. Souvent il poussait de forts mugissements," &c.—Dumortier, loc. cit., pp. 5 and 6.

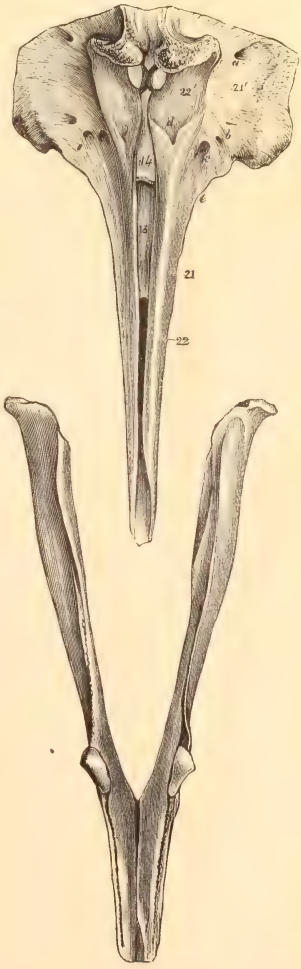
[3] "L'entré d'un canal, légèrement creusée en entonnoir."—Cuv., 'Oss. Foss.,' p. 58.

The sex of this individual is not noted; it differs from Sowerby's species (a male, fig. 13) in the much smaller size of the mandibular pair of teeth, which are similarly situated; but the specimen was rather larger. The smallness of the dorsal fin in both is indicated by the term '*micropterus*,' applied to the Havre Ziphial. This character may be more widely or generally manifested in the genus *Ziphius*.[1]

In the Anatomical Museum of Christchurch, Oxford, is preserved the portion of skull (fig. 14) of the species of *Ziphius* on which Sowerby founded his *Physeter bidens*, with a clear apprehension of its close and intimate affinities to the Cachalots. The specimen had been stranded on the west of Scotland (Elginshire ?). In the skull of this species, as in *Ziphius cavirostris*, Cuv., the premaxillaries (22) are separated from each other above for nearly the whole length of the rostrum, exposing (at 13) the upper canaliculate surface of the vomer, but including the proportion of the prefrontals which have been ossified into a dense convex tract at 14. The departure from symmetry in the naso-maxillary part of the skull is rather greater than in *Ziphius Arnouxii*, rather less than in *Z. Layardi*.

[1] See, *e.g.*, Dumortier, loc. cit., plate i, and the figure of *Ziphius* (*Ziphiorhynchus*) *patachonicus* in Burmeister's excellent 'Anales del Museo Publico de Buenos Ayres,' 4to, entrega quinta, 1868, pl. xv. On the 26th of May I was favoured by William Andrews, Esq., M.R.I.A., with a copy of his Memoir, from vol. xxiv (1869) of the 'Trans. of the Royal Irish Academy,' on *Ziphius Sowerbii*, "cast ashore in Brandon Bay, County of Kerry," Ireland. The specimen, like that found on the Elginshire coast, was a male; it "was about fifteen feet in length" (p. 7); the blow-hole was crescentic, with the horns turned forward; the mandibular tooth entered a notch of a thick padding of fibro-cartilaginous substance covering the alveolar border of that part of the upper jaw; it showed the usual sexual development and specific position; the summit of the crown was visible externally when the mouth was shut. Unfortunately the skin of the throat, as to the presence or otherwise of folds, and the fins, as to proportion, form, and position, were not subjects of observation.

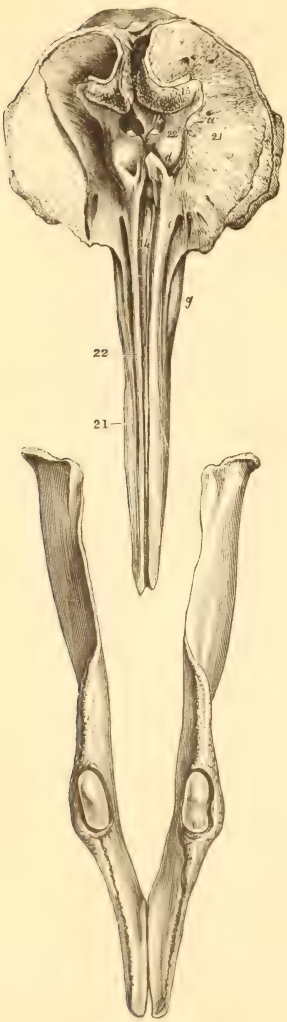
Fig. 13.



Ziphius Sowerbii.
Physeter bidens, Sow.
(*Mesodiodon Sowerbii*, Duv.)
(*Dioplodon Sowerbiensis*, Gervais.)
(*Diodon Sowerbii*, Jardine and Bell.)
(*Mesoplodon Sowerbiensis*, Gervais.)

Prof. Van Beneden figures a mandible of *Ziphius Sowerbii*[1] after a photograph of the original in the Museum of Christiania, transmitted to him by Prof. Boeck. The teeth are small, and situated a little nearer the hind part of the symphysis than in the Havre specimen (fig. 12), but it may well be a mere individual variety. The specimen was found on the coast of Norway, the sex unknown—may be inferred to have been female from the size of the teeth in the male, fig. 13, from our own coast, and as contrasted with the size of the teeth in the female specimen stranded at Ostend, and described by M. B. Dumortier.[2]

Fig. 14.



Ziphius densirostris.
Mesodiodon densirostre, Duv.[3]

Of the Cetacean representing the *Mesodiodon densirostris* of Duvernoy, the sex is unknown; the skeleton was sent by M. Leduc from the Séchelles Islands to the Garden of Plants, Paris, in 1839; it was most probably a male, showing a greater relative size of the developed pair of mandibular teeth than in *Ziphius Sowerbii*, with concomitant depth of the part of the jaw supporting them, chiefly due to growth of the alveolar border. But all this testifies to no more than specific value, if, indeed, it truly means that. The position of the teeth, more remote from the symphysis, tells better for specific distinction than their size.

A further degree of departure from symmetry than in *Ziphius Sowerbii* and *Z. micropterus* is manifested in the naso-maxillary region (fig. 14, 22'). The prefrontal (14) is ossified throughout its rostral extent, forming the summit of the ridge, a form which the compression and upward convergence of the premaxillaries (22) give to the upper surface of the ros-

[1] "Note sur un *Mesoplodon Sowerbiensis* de la côte de Norwege," in 'Bulletins de l'Acad. R. de Belgique,' t. xxii, 1866. Dr. Gray, in the '*Cetacea* of the Erebus and Terror,' pl. v, figs. 1 and 2, also follows De Blainville ('Nouvelle Dict. d'Hist. Nat.,' t. ix, p. 177) in giving a termination usually significative of locality—"*Sowerbiensis*;" I retain the common form, indicative of the individual—*Sowerbii*.

[2] 'Mémoires de l'Académie Royale de Bruxelles,' 4to, tom. xii, 1839.

[3] Ib., pl. ii, fig. 4.

trum. The upper mesial margins of the premaxillaries, toward the end of the rostrum, rise and converge above the prefrontal as in *Ziphius Layardi*, to which the present species is closely allied. The degree to which the end of the prefrontal subsides, the state of confluence therewith of the premaxillaries, and the extent to which they are naturally or actually apart at the end of the rostrum, can be determined only by inspection of the specimen itself. The rostrum shows the usual ivory-like or petrosal hardness indicated by the specific name.[1] The under part of the rostrum is convex transversely, and part of the vomer is there exposed. The antorbital foramen (*e*) is near the premaxillaries; the entry to the premaxillary canals (*d*) has the usual infundibular shape. Duvernoy approximates *Ziphius longirostris*, Cuv., to *Mesodiodon densirostris*, because it shows a similar ossification of the prefrontals (which he calls 'vomer') along the upper mid-line of the rostrum. But we see, as in *Ziphius indicus* (fig. 8), that this condition may be associated with a comparatively short and thick rostrum.

The *Mesoplodon* of Gervais is the *Mesodiodon* of Duvernoy. I may add that, at p. 60 of his Memoir (loc. cit.), Duvernoy cites, as one of the generic characters of *Mesodiodon*—"Les intermaxillaires, élargis à la base du rostre ont le trou, en entonnoir que distinguent les espèces de ce genre;" but on this ground *Choneziphius* must be transferred to *Mesodiodon*. In truth, however, the funnel-like expansion into which the premaxillary foramina (*d*) open characterises, with a certain range of variety, the Ziphials generally.

Choneziphius, *Duvernoy*.—Of Cuvier's *Ziphius planirostris* Duvernoy makes his genus *Choneziphius*, acknowledging, however, that the premaxillaries "sont creusés d'une cavité en forme d'entonnoir" (p. 61, as, indeed, Cuvier had expressly pointed out), which character Duvernoy had previously made a distinction of the species of his genus *Mesodiodon*, which includes, apparently, on that account, Cuvier's *Ziphius longirostris*.

The dense petrous ossification of the mid upper tract of the rostrum, due to the prefrontals, Duvernoy attributes to the 'premaxillaries' (p. 61), as in *Ziphius longirostris* he ascribes it to the 'vomer' (p. 60).

Placoziphius, *Van Beneden*.[2]—This genus is represented by a fragment including the base of a fossil rostrum discovered by Colonel Le Hon in an old deposit ('le crag noir' or stage of the Neozoic series, at Edeghem, near Antwerp. In the breadth and superior flatness of the preserved back part of the maxillaries this fossil resembles *Ziphius planirostris* and *Z. planus*. The prefrontal cartilage has not been ossified; consequently there is, as in *Ziphius Sowerbii*, fig. 13, and *Z. Arnouxii*, fig. 11, a vacant channel ("le canal vomérien," V. Ben.) between the premaxillaries, the bottom of which canal is formed by the superior vomerine groove. The expanded prenasal parts of the premaxillaries show the foramina

[1] Originally imposed on it by De Blainville.

[2] Van Beneden, "Sur un Nouveau Genre de Ziphioïde fossile (*Placoziphius*)," in 'Mémoires de l'Academie Royale des Sciences, &c., de Belgique,' tome xxxvii, 1866.

answering to those marked *d*, in the illustrations of this Monograph (*Ziphius Layardi*, Pl. I, fig. 2, *d*, et passim), opening or commencing, as usual in *Ziphius*, at the fore end or apex of an infundibular cavity. The right premaxillary is unsymmetrically expanded in the narial region. The maxillaries are too much mutilated to show the position of the antorbital foramina (*b*, *b*, in the figures of the present Monograph), but the outer margin of the maxillaries is grooved, as usual, by "un sillon très-marqué," answering to *e*, *g*, of the same figures.

The vomer puts in a carinate appearance on the palate, nearer the palatine bones than in *Ziphius Layardi;* but this is a difference of barely specific value when unassociated with better characters. The constituent bones of the fossil fragment of rostrum described and figured by Prof. Van Beneden (op. cit.) appear to have been in some degree separated from each other, indicative, like the separate state of the atlas, of the nonage of the individual. How far the non-ossification of the prefrontal cartilage may bear the same interpretation may be questioned.

The rostrum is restored (pl. i, fig. 1, vol. cit.) by continuing forward the lateral contours of the maxillary parts of the preserved base of the snout with the same degree of convergence to the problematical end, which, of course, makes the snout abnormally short for a Ziphioid. One sees, however, how deceptive such basis of restoration may be, by continuing, in like manner, the lateral contours of the expanded parts of the maxillaries forming the base of the prolonged rostrum in most of the *Ziphii* figured in the present Monograph.

This at least may be safely affirmed, that it is somewhat premature to propose a new genus of Cetacean on the fragmentary and decomposed fossil representing the *Placoziphius Duboisii* of Van Beneden.

Ziphiopsis, *Du Bus*.—The first character assigned to this genus[1] raises the question whether 'proportionate length of rostrum' be available for generic distinction. The inadequacy, to that end, of 'direction of rostrum,' in view of the slight deviations from straightness hitherto observed in recent and fossil Ziphioids, has already been mooted. I note, also, that examples cited of the genus *Ziphiopsis* do not give the length of the rostrum. *Z. phymatodes*, e. g., is represented by a fossil rostrum with the end broken off.[2] If the end of the rostrum of *Ziphius Layardi*, e. g. (Pl. I, fig. 3), were broken off anterior to the vomer (13), it might seem to have had one of but moderate length.

[1] "Rostre de moyenne longueur, droit, à peu près aussi haut que large. Maxillaires supérieurs très-épais. Canal vomérien petit. Incisifs médiocrement développés, à bords internes soudés ensemble dans toute leur partié rostrale, depuis la fosse prénasale jusqu'à la pointe."—'Bulletin de l'Académie Royale des Sciences, &c., de Belgique,' tom. xxv, p. 628.

[2] "Le vomer apparaît à la surface palatine, vers le milieu de la longueur du museau, et disparait vers son extrémité, entre les orifices antérieures des canaux palatins. Un peu au delà la pièce est brisée."—p. 628. A second specimen is only "un peu plus complet."—Ib. My experience warns against inferring the length of the rostrum in a *Ziphius* in a specimen not having that part entire.

As to the character of interconfluence of the premaxillaries at the region of the prenasal fossa, it may be permitted to doubt whether an intervening ossific production of the prefrontals, as at 14, Pl. I, fig. 2, Pl. IV, fig. 3, and in woodcut, fig. 13, 14, has not been so interpreted.

Of the second representative of *Ziphiopsis* (*Z. servatus*) the author knows but a single fragment of rostrum 'presque entier à sa pointe' (l. c., p. 629), and broken off in front of the prenasal fossa; it shows the same palatal portion of vomer as in *Ziphius Layardi*.

Rhinostodes, *Du Bus.*[1]—This genus is founded on a less compact or spongy texture of the fossil bones forming the mid-part of a much mutilated rostrum.

Ziphirostrum, *V. Ben.*[2]—In this genus the rostrum is straight, or bent slightly upward at the point. The maxillaries are more or less thick. The premaxillaries ('incisifs') are confluent along their inner borders at the mid-part of the rostrum, but distinct at the point. The vomerine canal is open; *i. e.* the premaxillaries are distinct or apart at their upper borders, the interspace not being occupied by an ossified prefrontal cartilage.

It is well that the direction of the rostrum is not seized as a generic character. Whether the degree of ossification of the prefrontal gristle be more entitled to serve as such is questionable. In some *Ziphirostra* the vomer appears as part of the palate, and, as usual, "un peu en avant du point occupé par l'extremité antérieure des palatins" (loc. cit., p. 624, *Ziphirostrum marginatum*, Du B.); and "dans le tiers moyen de la longueur de celui-ci" (ib., p. 623, in *Ziphirostrum Turninense*).

As to the confluence of the inner (mesial) borders of the premaxillaries, this, which first affects their lower margins, is an affair of age and a matter of degree, in fossil Ziphioids difficult to determine with any degree of certitude.

Aporotus, *Du Bus.*—This genus[3] has the same characters as *Ziphirostrum*, save that the inner borders of the premaxillaries in their rostral extent remain applied to one another without ever (?) becoming confluent.

[1] "*Rhinostodes Antwerpiensis*, Du Bus. Il n'existe au Musée qu'un seul fragment de tête de cet animal; c'est la partie moyenne d'un rostre extrêmement mutile." p. 629.—Recent *Ziphii*, as well as fossil ones, exhibit degrees of difference in the density of the tissue of the bones forming the rostrum. The prefrontal production appears to have been ossified in the portion of rostrum representing the genus *Rhinostodes*, Du B.

[2] "Genre *Ziphirostrum*, Van Beneden. Rostre droit ou légerement relevé vers la pointe. Maxillaires plus au moins épais. Incisifs soudés ensemble par leur bords internes, dans la partie moyenne du museau, mais séparé a la pointe. Canal vomérien ouvert."—"Sur differents Ziphiïdes nouveaux du crag d'Anvers," par M. le Vicomte Du Bus ('Bulletin de l'Académie Royale des Sciences de Belgique,' 2e série, tome xxv, 1868).

[3] "Le genre *Aporotus* a les mêmes caractères que le genre *Ziphirostrum*, sauf que les bords internes des incisifs, dans leur partie rostrale, restent appliqués l'un contre l'autre et ne sont jamais soudés ensemble." Loc. cit., p. 626.

The confluence or otherwise of borders in contact, even if known with certainty to be unaffected by the age of the individual, is not admissible as a generic character. Vte. Du Bus exemplifies his nominal genus exclusively by fossil rostrums. In some of the *Ziphii* associated under this head the vomer appears on the palate (*Aporotus recurvirostris*), in others not (*Ap. affinis*).

Ziphiorhynchus.—*Ziphiorynchus*, Burmeister,[1] founded on a female *Ziphius* stranded on the shore at Buenos Ayres, with a rostrum resembling in premaxillary and prefrontal modifications that of *Ziphius Gervaisii*, rests on the minute and concealed germs of teeth[2] for its generic distinction. One (terminal) pair of mandibular teeth are more developed, but only in the degree characteristic of the female sex. Burmeister has recorded valuable anatomical observations on this *Ziphius*; it accords with *Ziphius* (*Delphinorynchus*) *micropterus*[3] in the small size and position of the dorsal and pectoral fins, the dorsal being rather further back in *Ziphius patachonicus* than in *Z. micropterus*. The caudal fin is widely emarginate in both.

Belemnoziphius.—Professor Huxley contributes his mite to this array of names by proposing the genus *Belemnoziphius* for those species in which "the vomer occupies fully a third of the width of the upper face of the rostrum," the extremity of which "is entire, not bifid, but sharply pointed, almost like the end of the guard of a Belemnite, the vomer and premaxillæ seeming to coalesce into one solid terminal cone."[4] Unless the prefrontal has been mistaken for the vomer, I have not seen any specimen of *Ziphius* or Ziphioid Cetacean presenting these characters, and can only remark that they appear to exemplify rather a phase of anatomical knowledge of the individual than a power of recognising a genus.

A few words may be permitted, in conclusion, in reference to the first-described specimens on which our earliest knowledge of Cetacean remains in the Red Crag deposits was founded.

Dr. Bowerbank or Mr. Charlesworth would be able to say how long, and through how many hands, the fossil (fig. 226, p. 536, 'British Fossil Mammals,' 1846) in Mr. John Brown's (F.G.S., of Stanway) Collection, now in the British Museum, Register No. 27,862, had been passing, without any clue having been caught as to its nature, before the amorphous *unicum* came, in 1840, into mine, with permission from the possessor to slice and apply to it the microscopic test. If the palæontologist cares to turn to the

[1] 'Annals and Mag. of Nat. Hist.,' 1866, pp. 94 and 303.

[2] 'Anales del Museo Publico de Buenos Ayres,' entrega quinta, 4to, 1868, pl. xix, fig. 4; pl. xix, fig. 6.

[3] "Mémoires sur le Delphinorhynque microptère échoué à Ostende," par B. C. Dumortier ('Mémoires de l'Académie Royale de Bruxelles,' tom. xii, 1839).

[4] "Proceedings of the Geological Society," May 25th, 1864 ('Quarterly Journal of the Society,' vol. xx, p. 392).

page above cited, he will be puzzled to understand the note purporting to afford the 'unde derivatur' of the generic name under which it is there described. The truth is that, having detected its nature as a tooth, and the affinity in structure to the physeteroid type of Cetacean teeth, I suspected it might have belonged to one of the ziphial divisions of *Physeteridæ*, and named it in the first instance *Ziphiodon*, as the note tells, from "*Ziphius*, generic name of a fossil Cetacean, and ὀδους, a tooth."

Subsequent acquisitions of fossil petrotympanic bones from the same deposit and locality as those to which Mr. Charlesworth had traced the tooth in question, and some of the larger of which 'Cetotolites' showed the more simple balænoid type of form as contrasted with the division of the involute convexity into an outer and inner lobe, and the non-continuation of the overarching wall around the inner end of the cavity, characteristic of 'Cachalots' and Ziphial ear-bones, induced the suspicion that the fossil tooth in question, from its agreement in size with those balænoid ear-bones, might appertain to some such species, more especially as the cetotolites of the Cachalot type from the 'Red Crag' were much smaller in size; and, at the last hour of going to press, I gave this doubt its benefit; but omitted to erase from the proof-sheet the note explaining the first imposed generic name. In this stage of knowledge of detached, fragmentary, and scattered fossils one can only suggest a guess, nor did I assume to give more, by the light of the analogies detailed in pp. 340 and 341, than "a dim and distant view of the actual generic characters of creatures revealed to us by a few fragments of their fossilized skeletons, which have been bruised and worn by ages of elemental turmoil."[1]

Unremitted attention to the Mammalian fossils of the Red Crag has failed, hitherto (1868), to add to the grounds for determining the generic nature of the tooth referred by me, in 1840, to a *Ziphiodon*, and subsequently, in 1846, to a *Balænodon*.

It is affirmed by E. Ray Lankester, Esq., in a paper on Crag *Mammalia*, in 'Quart. Journal Geological Society' for February 8th, 1865 (p. 231), on the authority of M. Van Beneden, "that the Balænodon teeth of the first form (that originally described) are, without doubt, the teeth of the bident lower jaws of those Ziphioids whose remains occur with them in the Red Crag."

The reception of the evidence, when the experienced Cetologist of Louvain may have the leisure to publish it, proving beyond doubt that the tooth in question belongs to a *Ziphius* of the Red Crag, will be most acceptable. In the meanwhile, however, I cannot help resting in the same state of uncertainty, oscillating, as it were, between *Ziphiodon* and *Balænodon*, as from the years 1840 to 1868. And I have the greater difficulty in extricating myself from this expectant state of mind, because of the number of distinct species of *Ziphii* which, in that interval of time, I have been able, I trust, to define to the satisfaction of palæocetologists. When M. Van Beneden's demonstrations reach us, we shall know to which of the species (or Grayan genera) of British Red Crag Ziphials the tooth of *Balænodon* belongs.

[1] Op. cit., p. 541.

There is a vagueness, unfortunately, in Mr. Ray Lankester's announcement of M. Van Beneden's discovery that of itself begets hesitation. Mr. Brown's old fossil cannot be one of the "teeth of the bident lower jaws of 'all' these Ziphioids whose remains occur with them in the Red Crag." At least, the analogy of the range of variety in size, shape, direction, and position, of the teeth in the bident lower jaws of existing species (genera) of Ziphials would lead us to infer something of the same kind in the fossil species (genera). Then, again, recurs the undoubted fact that *Cetacea* of another family, so far as cetotolite characters teach, have also left their remains in our Red Crag.

When M. Van Beneden adduces as an argument, removing all doubt of the belonging of a Balænodon tooth to the Red Crag *Ziphii*, that it "occurs with them in the Red Crag," does he mean to say, as his reporter would have us to understand, that they are so associated in closer and more demonstrative relation with the unquestionable snouts of *Ziphii* than they are with the unquestionable ear-bones of Balænoids? I have not, as yet, obtained the requisite evidence of the fact, and I may aver to have had as much personal experience in exploring and collecting from Red Crag localities as either M. Van Beneden or Mr. Ray Lankester.

Again, the latter affirms, on M. Van Beneden's authority, with respect to the second kind of cetacean Red Crag teeth, "more elongate and with an emarginate nipple-like crown of enamel," that they are, without doubt, the teeth of a species of *Squalodon*.[1]

The grounds that lead me still to entertain doubts on this point are given at page 26, in connection with comparisons with a recent Ziphial tooth (see Pl. I, figs. 4 and 5) having unquestionably the character above cited; and I may add that, of the truly characteristic and most numerous compressed, two-fanged, serrated teeth of *Zeuglodon* (= *Squalodon*, V. B.), I have not as yet seen any specimen from our English Red Crag deposits. No doubt it is a telling, as it is a sweeping, conclusion from the *on dit* of the experienced and accomplished Louvain cetologist that '*Balænodon physaloïdes*' must be "removed from the list of our British fossil Mammals;"—but it is not science.

[1] 'Quart. Journ. Geol. Soc.,' 1865, p. 231.

PLATE I.

Ziphius Layardi.

Fig.

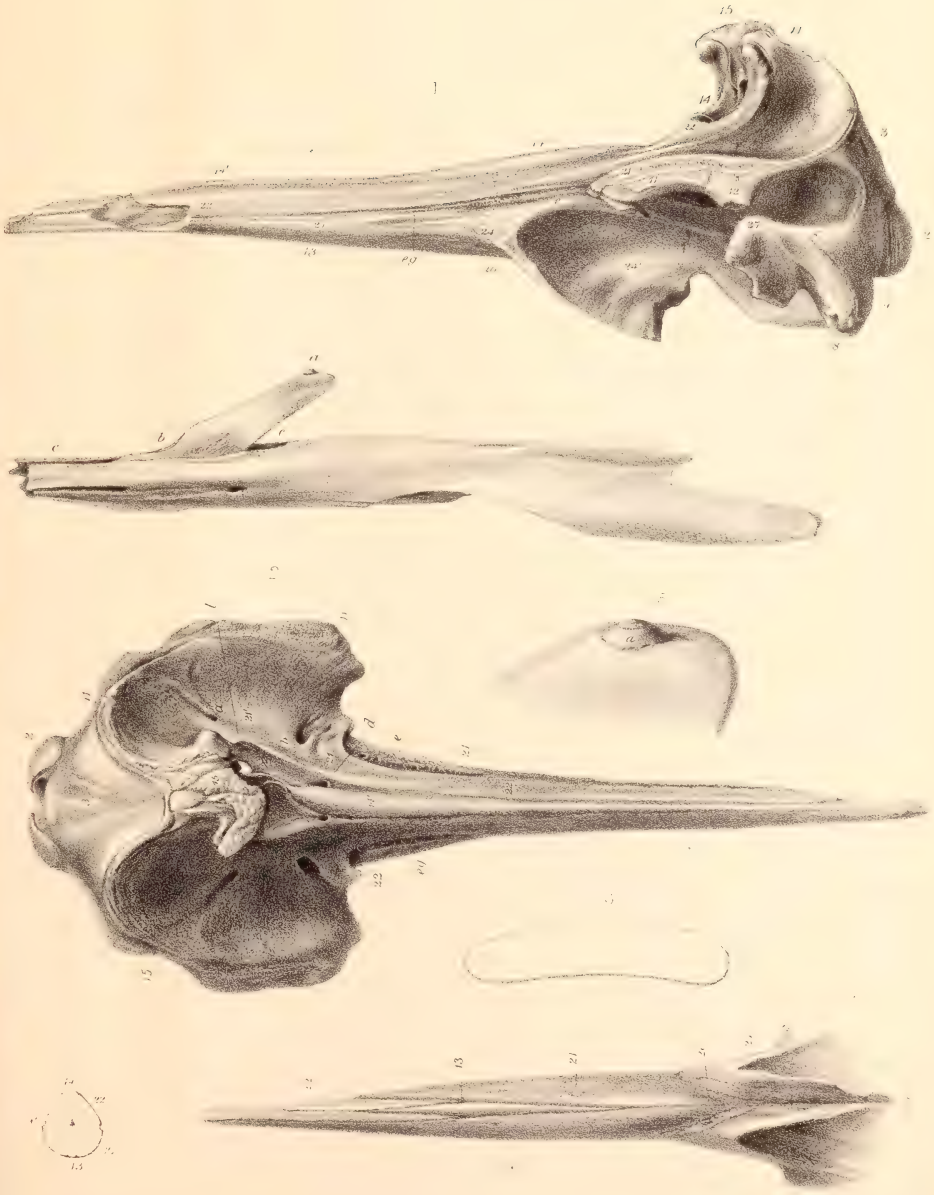
1. Side view of skull.
2. Upper view of ditto.
3. Under view of rostrum, with section of ditto at *, in outline.
4. Side view of mandible (parts broken restored in outline).

These figures are 1-6th nat. size.

5. Summit of developed mandibular tooth, showing enamelled crown or portion, *a*, nat. size.
6. Transverse section of mandibular tooth, nat. size.

A recent species, from the Cape of Good Hope.

[The letters and figures are explained in the text.]



ZIPHIUS LAYARDI.

Dinkel del.

W.West. imp.

PLATE II.

Ziphius planus.

Fig.

1. Upper view of basal part of rostrum.

Ziphius gibbus.

2. Upper view of rostrum, wanting the extremity.

2*. Outline of transverse section of rostrum at the part marked * in fig. 2.

Fossils, from the Red Crag of Suffolk. In the British Museum.

PLATE III.

Ziphius angustus.

Fig.

1. Side view of basal portion of rostrum.

2. Upper view of ditto.

2*. Outline of transverse section of ditto at the part marked * in fig. 2.

Ziphius gibbus.

3. Side view of basal portion of rostrum.

3*. Outline of transverse section at the part marked * in fig. 3 (upside down).

Fossils, from the Red Crag of Suffolk. In the British Museum.

PLATE IV.

Ziphius angulatus.

Fig.

1. Upper view of rostrum, wanting the end.

2. Side view of ditto.

2*. Outline of transverse section at the part marked * in fig. 1.

Ziphius medilineatus.

3. Upper view of rostrum, wanting the end.

3*. Outline of transverse section of ditto at the part marked * in fig. 3.

Fossils, from the Red Crag of Suffolk. In the British Museum.

PLATE V.

Ziphius tenuirostris.

FIG.

1. Side view of rostrum, wanting the end.

2. Upper view of ditto.

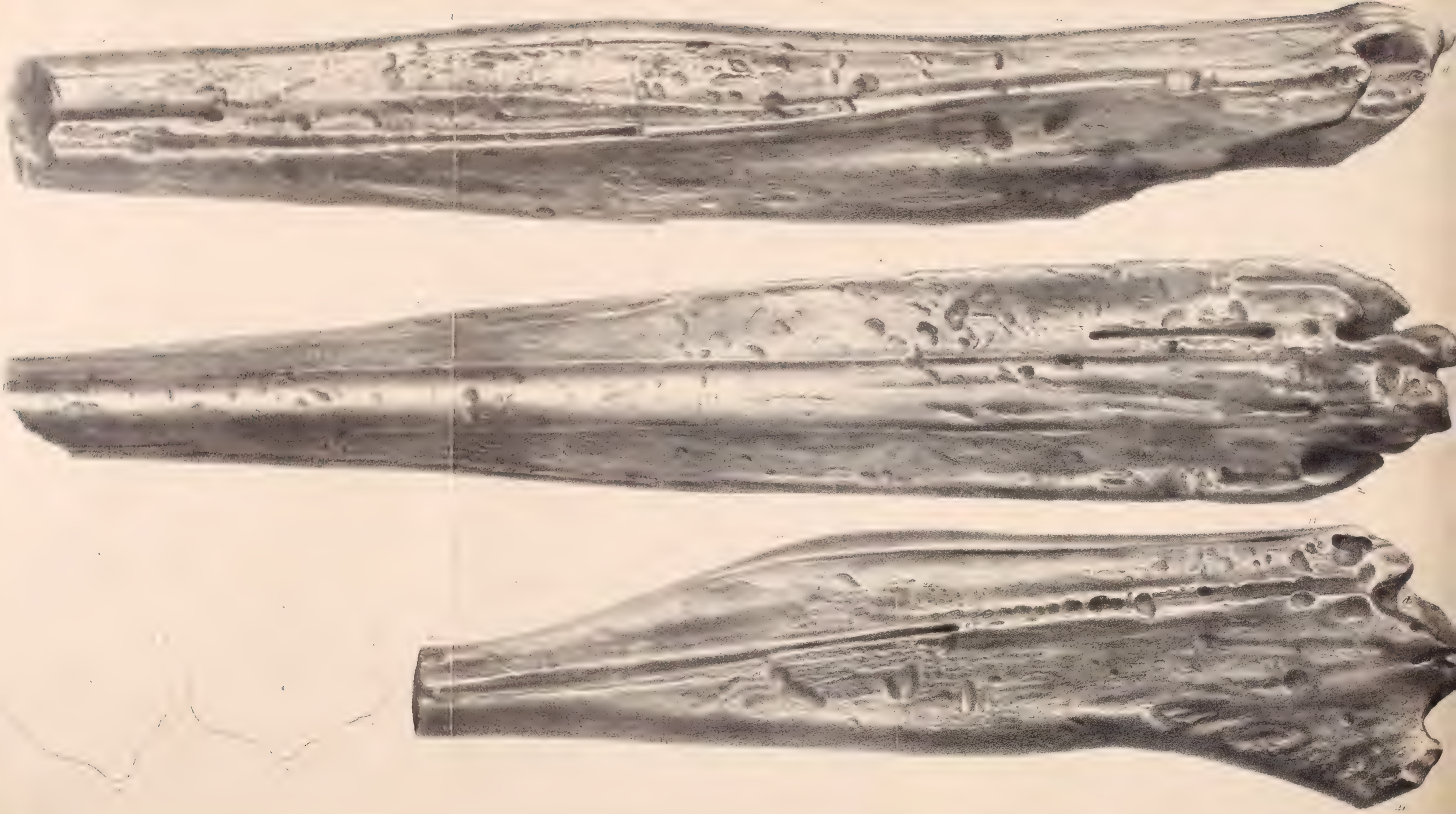
2*. Outline of transverse section of ditto at the part marked * in figs. 1 and 2.

Ziphius compressus.

3. Side view of rostrum, wanting the end.

3*. Outline of transverse section of ditto at the part marked * in fig. 3.

Fossils, from the Red Crag of Suffolk. In the British Museum.



Palaeontographi
JUN 1 1967

THE BOUND TO PLEASE Heckman Bindery INC. N. MANCHESTER, INDIANA JUNE, 65

AMNH LIBRARY
100126826